This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

Google books

https://books.google.com

NYPL RESEARCH LIBRARIES
3 3433 10765 0628

Digitized by Google

018

Digitized by Google

Geological

PTA

Digitized by Google

018

Digitized by Google

Geology

PTA

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

INDEXED
EV. K
LIBRARY
LENOX AND
FOUNDATIONS
695455

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. XII.—PART I.

1899-1901.

GLASGOW: PUBLISHED BY THE SOCIETY,
AT ITS ROOMS, 207 BATH STREET.
1902.

Wm. Hodge & Co.,] [*Printers, Glasgow.*

PTA
Geological. PTA
Digitized by Google

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

Digitized by Google

NEW YORK
PUBLIC
LIBRARY

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW

VOL. XII.

1902-1905.

GLASGOW: PUBLISHED BY THE SOCIETY,
AT ITS ROOMS, 207 BATH STREET.
1905.

Digitized by Google

THE NEW YORK
PUBLIC LIBRARY
695455
ASTOR, LENOX AND
TILDEN FOUNDATIONS
R 1914 L

The Editors beg to state that the Authors are alone responsible for the facts and opinions contained in their respective papers.

PETER MACNAIR, F.R.S.E., F.G.S.
FREDERICK MORT, M.A., B.Sc., F.G.S.

NEW YORK
PUBLIC
LIBRARY

Digitized by Google

NEW YORK
PUBLIC
LIBRARY

Digitized by Google

NEW YORK
PUBLIC
LIBRARY

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

Digitized by Google

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. XII.—PART I.

1899-1901.

GLASGOW: PUBLISHED BY THE SOCIETY,
AT ITS ROOMS, 207 BATH STREET.
1902.

Digitized by Google

The Editor begs to state that the Authors are alone responsible for the facts and opinions contained in their respective papers.

JAS. BARCLAY MURDOCH, F.R.PH.S.E.

Digitized by Google

CONTENTS—Vol. XII., Part I.

PAPER		PAGE
I.	The Mineralogy of the Faröe Islands. By the late M. Forster-Heddle, F.R.S.E., &c., *Hon. Member*,	1
II.	The Lower Carboniferous Rocks of Northern Britain. By J. G. Goodchild, F.G.S., F.Z.S., of the Geological Survey, Curator of the Scottish Geological Collection in the Museum of Science and Art, Edinburgh. With two Diagrams, and a Section [Plate I.],	16
III.	Boulders and other Evidences of Ice-action in Lochaber. By Colin Livingston, *Cor. Member*, Fort-William. With a Map [Plate II.],	39
IV.	The Surface Geology of the Falls of Clyde District. By James Stark, *V.P.* With a Map [Plate III.],	52
V.	The Gold-field of N.-W. Ontario, Canada. By R. W. Dron, Assoc. M. Inst. C. E.,	58
VI.	A Group of Short Papers. By John Smith:—	
	(1) On a Flexed Structure in the Pitchstone of Corriegills, Arran. With a Diagram. (Summary),	61
	(2) On Drawn-out Spherulitic Structure in a Trap Dyke near Balloch Pier, Great Cumbrae. With two Diagrams. (Summary),	62
	(3) On Globular Structure in a Trap Rock near Neilston, Renfrewshire. With a Section,	62
	(4) On Volcanic Ash with Beds of Sand and Gravel, near Neilston, Renfrewshire,	63
	(5) On a Freshwater Limestone underlying a Marine Limestone, near Paisley,	64
	(6) On the Boulder-clay at Hamilton Hill, North of Glasgow,	65
VII.	The Carboniferous Limestones of Scotland, with their Coals. By R. W. Dron, Assoc. M. Inst. C. E.,	66
VIII.	The Shore Section at Portincross, Ayrshire. By James Stark, *V.P.* With a Section,	74
IX.	Notes on a Recent Excavation in Sauchiehall Street, Glasgow. By John Wallace,	79
X.	The Geology of the Elvanfoot to Wanlockhead Railway (with Special Reference to the Drift). By John Smith,	81

Digitized by Google

PAPER PAGE

XI. Notes on the Development of "Ausweichung" or Strain-slip in Schistose Rocks. By Peter Macnair, *Assist. Hon. Secretary.* (Summary), - - - - - - - - 89

XII. The Drainage of the Nile Valley. By Matthew Blair, *V.P.* (Summary), - - - - - - - - - - 90

Proceedings for the Forty-second Session, 1899-1900, - - 92

Report of the Council for 1898-1899, - - - - - - 92

Report on the Library for 1898-1899, - - - - - - 94

Proceedings for the Forty-third Session, 1900-1901, - - 104

Report of the Council for 1899-1900, - - - - - - 104

Report on the Library for 1899-1900, - - - - - - 106

Excursions for the Season of 1899, - - - - - - - 115

Evening Excursions in 1899, - - - - - - - - 117

Excursions for the Season of 1900, - - - - - - - 118

Evening Excursions in 1900, - - - - - - - - 122

Abstract of the Treasurer's Accounts for 1899, - - - 123

Abstract of the Treasurer's Accounts for 1900, - - - 124

Objects of the Society, - - - - - - - - - 126

Constitution and Laws of the Society, - - - - - 127

Office-bearers of the Society for Session 1901-1902, - - - 134

List of Members of the Society, May, 1902:—

Honorary Members, - - - - - - - - - 135

Honorary Associates, - - - - - - - - 135

Corresponding Members, - - - - - - - - 136

Ordinary and Life Members, - - - - - - - 136

Publications of the Society, - - - - - - - - 144

Digitized by Google

ILLUSTRATIONS—Vol. XII., Part I.

			PAGE
Plate I.	Comparative Sections of Lower Carboniferous Rocks, drawn to the same scale, taken from Clitheroe through the Border Counties to Edinburgh and Glasgow,	*to face*	22
,, II.	Map of the Lochaber District,	,,	50
,, III.	Map of the Falls of Clyde District,	,,	56

Sections and Diagrams in the Text :—

Section across the Solway from West Cumberland to Dumfriesshire,	25
Crescentic Zones of Subsidence,	27
Flexed Structure in Arran Pitchstone,	61
Drawn-out Spherulitic Structure. Two Diagrams,	62
Diagrammatic Section of a 6-feet Trap Ball,	63
Shore Section at Portincross, Ayrshire,	75

Digitized by Google

WILLIAM HODGE & CO., PRINTERS,
GLASGOW AND EDINBURGH.

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

No. I.—The Mineralogy of the Faröe Islands. By the late M. Forster-Heddle, F.R.S.E., &c., *Hon. Member.*

[*Introductory Note.*—The Faröes are a group of islands in the North Atlantic Ocean which belong to Denmark. They lie between Lat. 61°20 and 62°20 north, intersected centrally by Long. 7 west, and about 170 miles north-west of the Shetland Islands. They are 22 in number, and of these 17 are inhabited. The whole group stretches about 65 miles from north to south, and 44 miles from east to west, and forming something like a triangle with the apex to the south.

The largest island is Stromsöe, which is in the centre of the group, with an area of 104 geographical square miles; the other larger ones being Osteröe, Suderöe, Sandöe, Vangöe, and Bordöe, with an aggregate area of 376 geographical square miles.

The islands generally present steep and lofty precipices to the sea, which running between them often forms fiords and bays in which good anchorage is found. The surfaces rise towards the interior and terminate in peaks. Of these the culminating one is Slatteretind, in Osteröe, with a height of 2800 feet.

The climate being insular, is much milder than the latitude might seem to indicate. The soil has sometimes a depth of 4 feet, but for the most part is thin, and often does not exceed 6 inches.

The capital is Thorshavn, in Stromsöe, and the total population is about 8000. Ed. 1902.]

Digitized by Google

Notwithstanding their prolific yield of minerals, the islands of Faröe have never been examined with much care. The late Mr. Alexander Rose, Lecturer on Mineralogy, and Dealer in Minerals in Edinburgh, informed the present writer that Count Vargus Boedemar spent some short time in them when returning from an exploitation in Iceland. Sir George Mackenzie has given some scanty information regarding their minerals in the *Transactions of the Royal Society of Edinburgh.* Mr. Alexander Bryson visited them more lately, but confined his observations to their geology.

In 1856 I induced my friend, the late Mr. Dudgeon of Cargen, Dumfriesshire, to associate himself with me in a more persistent assault upon their rocks. A cutter of 48 tons was chartered, her crew strengthened, a quarryman engaged, blasting and heavy mining tools provided, and the vessel specially fitted for the storing and conserving of the spoil.

The consent of the Governor of the Islands was next secured. Most unfortunately, at the last moment, Mr. Dudgeon found himself unable to accompany me; but I was fortunate in securing the companionship of Mr. August Randrop, son of the Fiscal of the islands—an excellent general naturalist, and a good linguist.

Several months were spent in the islands—more than twelve barrels full of minerals secured—while the notes which follow present, in a condensed form, the information gained.

Island of Naalsöe.

From the northern escarpment of the hill south of Eide—the highest hill of the island—a number of large blocks and a considerable quantity of debris had fallen. From amongst this there was picked up a specimen of Chabazite. This was very markedly the finest specimen which the writer has ever seen, and was nearly 6 inches in length by 2½ in width. Its surface was covered with small crystals of pellucid blue Chabazite. Upon these were disposed some five or six crystals of the same mineral, in almost perfect crystalline relief, from ⅝ to almost an inch in length, and of a pure milk-white colour and opacity. The edges and angles were absolutely sharp and untruncated.

At that part of the western coast-line which forms a promontory almost opposite to Thorshavn the writer found Pectolite in a vein

Digitized by Google

in a little cliff—or piece of rocky ground which faced the north. It was from 4 to 6 inches in width, and ran from east to west for a few feet. The mineral was broken out with great difficulty, as both it and the rock which contained it were of extreme toughness. It was lined on both sides by very minute crystals of Heulandite. The fibres or acicular crystals which formed it diverged from its sides towards its centre. Viewed by transmitted light it is singularly pellucid or porcellaneous. Much of this vein still remains.

The Great Cave of Naalsöe.

This locality, although it does not afford either many or rare species, must still be regarded as one of the most important in Faröe on account of the abundance of the specimens there found. These will be considered in the order of their nearness to the rock when occurring together in one and the same cavity.

Chabazite.—Though fairly brilliant from the high polish of the surfaces of its crystals, the specimens of this mineral which are here found cannot be regarded as particularly fine. The crystals are rarely over $\frac{1}{8}$ of an inch of uniform size; they are intersprinkled with small isolated hemispheres of Faröelite, forming a pleasing association.

Faröelite.—Under its old name of "Mesole" this mineral used to be confounded with Mesolite. In the year 1857 the present writer showed it was specifically different therefrom.* Dana thereafter showed that it was a super-silicated variety of Thomsonite. In the Hebrides true Thomsonite very rarely occurs; sometimes in not very distant association with Faröelite, from which it may be distinguished by the latter either occurring in solid spheres, or as a continuous coating of the rock, and very rarely, as in this case, forming stalactites.

The Thomsonite of this formation is in very minute and loosely aggregated sheaves of minute crystals—in fact this super-silicated variety may be looked upon as specially the Thomsonite of Tertiary volcanic rocks. It is probably the most frequently-occurring zeolite in the Faröes, and certainly so at this locality, there being hardly a druse which does not contain more or less of it. It presents itself here with two widely different appearances: in the

* *Philosophical Magazine*, January, 1857.

Digitized by Google

first it is seen in more or less isolated globules approaching ½ an inch in diameter. These are bluish-white in colour. This variety is generally unassociated with other minerals.

This was analysed and contained—

Silica.	Alumina.	Lime.	Soda.	Water.	Total.
42·50	28·06	11·35	5·60	13·02	100·53
42·60	20·00	11·43	5·63	12·70	100·36

The second analysis was one by Berzelius, probably also of a specimen from this locality. The second variety of Faröelite, namely, that investing druses (and these by the way are those generally of large size), has a somewhat yellow or brown tint; and this latter variety usually has as associates either Chabazite, Apophyllite, or Stilbite.

Native Copper, in thin sheets and minute octohedra, rarely is associated with the Faröelite.

Apophyllite.—This also occurs here of two very different appearances. In the first of these it is in very minute crystals not thicker than a knitting needle, and of the third of an inch in length. These are generally doubly terminated, and of the form *a p c*. They are usually perfectly colourless and transparent; but occasionally they have a pale green tint. It was in crystals from a specimen from this locality presented to Sir David Brewster by the late Dr. Macdonald, Professor of Natural History in the University of St. Andrews, that the former discovered the marvellously intricate and beautiful structure, as disclosed by polarized light, which he has described and drawn in the *Transactions of the Royal Society of Edinburgh.*

An extension of this structure has been seen by the writer in crystals collected here. These transparent crystals are usually attached to the Faröelite by the face *a*, and so can be easily detached. Occasionally they are superimposed upon each other with hardly any attachment.

In its second variety the Apophyllite occurs in much larger crystals, the average thickness being over ⅛ inch by ½ inch in length. These are milk-white and opaque, and are more or less embedded in the Faröelite. Specimens of all sizes, up to nearly a foot in diameter, can be obtained, and they form very interesting and characteristic illustrations of the mineral. The crystalline form is the same as that already mentioned.

Digitized by Google

Sphærostilbite.—This is the only locality in Faröe from which I have procured the substance or structure so named. It occurs in white nodules from the size of a marble to that of a very small egg. These are pure white and have an exceedingly rough and tufted surface. When broken, or rather when divided, the internal structure is seen to radiate from a centre. Close examination with a lens shows that they are made up of two minerals which are interstitially associated, and these two minerals are minute rough crystals of Stilbite and fibres of Mesolite which occasionally protrude from the surface of the spheres in downy tufts.

An analysis of the solid portion of the sphere gave a composition which was intermediate between that of Stilbite and Mesolite, while a quantity of the down gathered from the surface, which was snowy white and of a silvery lustre, and which the microscope showed to be quite pure, yielded on analysis—

Silica.	Alumina.	Lime.	Soda.	Water.	Total.
46·80	26·46	9·08	5·14	12·28	99·76

This is quite the composition of a typical Mesolite.*

Stilbite.—The specimens of this mineral from this locality are of great beauty. Two varieties also occur in the lower part of the cave and associated with Faröelite or with Faröelite and Chabazite; these are colourless, white crystals of the combination *a b m r*, or more rarely *a b c*; but from a cavity in the roof of the cave the writer obtained an unlimited supply of specimens up to nearly a foot in diameter, which were so studded with crystals of the first of these forms, and from an inch in length, that in the extracting of the specimens they fell over his shoulder like snowflakes, and were afterwards collected in hundreds. These crystals were of silvery lustre, and semi-transparent. When examined by polarized light with a low power in the microscope they exhibit a luminous cross tinted with faint colours.

It is worthy of record that when in the year 1857 this cross was shown to Sir David Brewster he instantly exclaimed,

* Vagöe and Dalsingpen are given as localities for Sphærostilbite by Dumeril. Vagöe I did not visit. At Dalsingpen I did not see it.

Digitized by Google

"I cannot understand or explain that cross unless by the supposition that it is a compound crystal." He thus anticipated Langemann and Lasaulx' discovery by many years.

Many of the druses in this cave are tubular in their proportions, running nearly horizontally into the rock.

Hypostilbite.—This substance, regarded as a species by Beudant and Dumeril (and whose analyses, it must be admitted, agree admirably), I could not satisfy myself to be established. Specimens which I had set down as being probably that to which the name had been given were found in the cave of Naalsöe. These, however, upon close examination proved to be only unusually large spheres of Sphærostilbite of a somewhat more solid and radiating structure, and larger size than the average. Analyses of portions from the centre and from the outside also gave results differing as much as from 50 of silica in the centre to 56·5 at the circumference.

The late Alexander Rose informed me that Count Vargus Boedemar, who, though he had collected both in Iceland and in Faröe, had never seen the mineral, and was doubtful as to its specific individuality.

Along with the late Mr. Alexander Bryson, to whom they were gifted, I carefully examined the specimens collected in Faröe by Sir George Mackenzie. There was nothing which in the least corresponded with it. Professor Jameson knew nothing as to it. And in no museum have I seen a specimen whose ticket bore the name. I therefore entirely doubt its specific individuality.

Upon the east side of the island, at a spot somewhat south of the lately-erected lighthouse, dendritic Native Copper occurs. It is always invested by Faröelite.

Bordöe.

South of the harbour of Waii, or Hoiwig, there towers a lofty hill—Haafield—capped with an almost inaccessible cliff. The debris which has fallen from this cliff when broken up yielded specimens of the following minerals:—

Chabazite.—In fine specimens of the primary form.

Stilbite.—With an unusual development more resembling

Digitized by Google

radiating crystals of Natrolite than any other mineral. The following analysis, however, proved it to be Stilbite:—

Silica.	Alumina.	Ferric Oxide.	Lime.	Potash.	Soda.	Water.	Total.
58·79	14·613	·47	9·534	·232	·324	17·298	101·261

The specific gravity was 2·103. This Stilbite was underlaid by small crystals of Heulandite. It itself was arranged in rosette bundles of crystals about $\frac{5}{8}$ inch long by $\frac{1}{16}$ in the other directions, and to the eye they appeared to be square prisms.

Levyne.—As is almost invariably the case this mineral here occupies druses, of which it is the sole occupant. Chabazite here

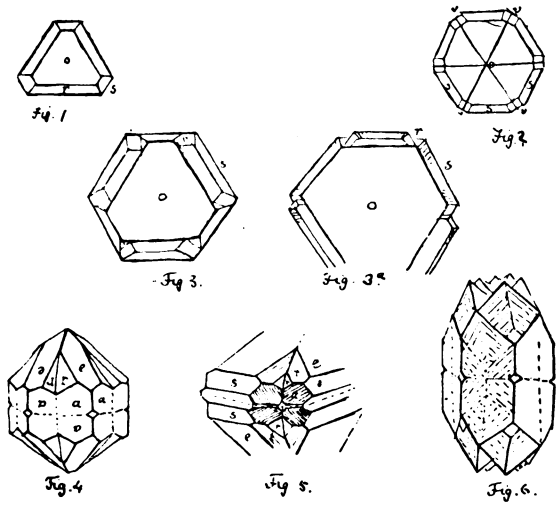


Diagram 1.—Crystallization of Faröe Minerals.

lines other druses, but the two are never associated. Although the crystals of Levyne are here small, yet the druses containing them are larger than any holding this mineral which I have seen elsewhere, either in Faröe or at other localities. Some of these druses attain a length of two inches. There are crystals of *o r s* (fig. 1); twins of *o s v* (fig. 2), simulating twins of Gmelinite; crystals of interpenetration of two individuals of *o r s* (fig. 3); but the ordinarily occurring form at this locality is a twin consisting of one large individual and three small ones,

Digitized by Google

which are much thinner than the first—the combination found in all is *o r s* (fig. 3*a*).

Heulandite is also here found in small crystals, of somewhat unusual development.

Osteröe.

Lambavig.—This bay being open to the south-east must be approached from Glibre. The west anchorage is inside of Sjör, in Köngshavn. In passing over or round the hill which lies between Glibre and Lanshavig, a cliffy escarpment will be seen on its north-eastern side. Here may be obtained specimens of Heulandite, *b s t c*, overlying Celadonite and generally underlying Chabazite of the primary form. Chabazite occurs here in most interesting forms. The primary *r* is usually twinned; other forms are *r e a* twins (fig. 4); twins of *r t e s a*, similar to fig. 4 of Greg, but having six crystals of intrusion on the *t* faces of the larger twin, as shown by the double re-entering angles at *a* (fig. 5). Then there are also twins of *t a* and *t a s*. One wonderfully intricate twin was found. Upon a simple large twin of *r t s a* there are set down in a rosette form twelve small crystals of *r t a*, with their *r* faces nearly parallel to *t* of the larger twins, and twelve minute crystals are set down on the *r* faces of the first twelve, eight of these being parallel with the edges, *a a*, of the large twins (fig. 6).

About the centre* of the south shore of Lambavig is situated perhaps the best locality known in Faröe for chalcedonic druses, as distinct from Onyx. These, however, are now rare and must be searched for by sounding the rock with a ponderous hammer. In a small cave here the writer laid open a large druse, which yielded the finest specimens of Chabazite which he has seen, except the specimen from Naalsöe. The crystals, from $\frac{5}{8}$ inch down to $\frac{1}{4}$ inch, were milk-white, and were sprinkled over a basement layer of Celadonite sheathed in transparent Chabazite, microscopic in the size of its crystals. The cavity was filled with several gallons of water.

Eide.—In the neighbourhood of this northern village there are

* Sir George Mackenzie's locality, seemingly a still better one, was near the hamlet of Lambavig.

Digitized by Google

two mineral localities. This one lies upon the eastern shore of the promontory of the Kodlin. Here Gyrolite in pea-sized globules is to be found, associated with indifferent specimens of other minerals.

The summit slopes of the hill lying immediately south of Slatteretind is sprinkled with debris, amongst which may be found much Onyx and Girasol Opal of white and yellowish colours. Examination with the microscope discloses that the milkiness of the Cacholong, which causes the white banding of the Opal, is due to an intermixture of Girasol Opal with Chalcedony in ovoidal forms, and radiating fibrous structure. The Opal from this locality is so fragile that it cannot be used for jewellery.

A cave at the east foot of the Kodlin, only accessible by boat, afforded fine specimens of pellucid Calcite.

Stromsöe.

A locality called Hoiwig, some three miles north of Thorshavn, yields indifferent specimens of Chabazite, Heulandite, and Faröelite.

Dalyspen.—This locality is best approached from an anchorage at the head of Halbaksfiord, and ascending by a stream which descends the hill on the left until Norderdahl is reached. The best mineral locality is about the cliff-edge westward of this. This is the locality generally given for Levyne. Little else is to be found, and the specimens are small at the best.

Odnadahlstint, Kollafiord.—Good holding ground can be got a little above Sjör, and although the hill itself may be somewhat nearer to Thorsvig, yet as the Opals got here are regarded as private property, and as the proprietor of the ground resides at Sjör, it is right to obtain his consent, and well to secure his guidance in the search for them.

The Opals of Faröe are all of the Girasol variety—at least the writer has never seen any with internal fire. For the most part they are milk-white, and for the most part they are valueless—as from, apparently, some tension which they retain for some time after they are extracted from their matrix, they crack and occasionally fly to pieces while being polished. The only fragments which the writer has succeeded in cutting and polishing were such as had lain exposed to the weather; some of these by transmitted sunlight had a feeble amount of red

Digitized by Google

brilliance; and such as had a narrow vein of brown tint might, if in sufficient amount, be utilised for such ornaments as bracelets. The usual colours are milk-white and faint yellow. Fire Opal is said to occur, and in the surrounding hills—for Odnadahlstint is merely the centre of a somewhat wide space in which they are found—the specimens are, however, more of the nature of a reddish Wax Opal, and the druses which they fill are seldom of the size of a bean.

From the above somewhat disparaging remarks upon the Opals of Faröe there are two varieties which must be excluded, as each is in its own way altogether unique and magnificent. As I have not myself found them either here or in any part of the islands I cannot give their locality. The first is the Green Opal of Faröe, the colour being due to a wonderfully uniform admixture of Celadonite; the second, the Banded or Ribbon Opal in which a uniform mass of milky-white has a band of translucent reddish-brown. Both of these are unrivalled.

Kvalvig.—This is the anchorage from which the cliffs surrounding the bay of the same name may be examined. The escarpments surmounting the tillage at Stromness yield Chalcedonies, Onyx, and all their varieties in great amount. These are generally to be extracted in the form of short pillars, the Onyx banding being transverse and always strictly horizontal —the stalactites, where present, equally strictly vertical. It was from these cliffs that were obtained what the writer regards as the finest specimen of Onyx ever known.

From the banks of a stream facing these cliffs on the south of the valley, and about 300 feet above sea-level, several solid druses of Okenite from 3 to 8 inches in diameter were extracted. The fracturing of the largest of these masses almost defied the efforts of half-a-dozen men and a 28-lb. hammer.

Saxen.—This village lies some eight miles to the north-west of Kvalvig. Half a mile nearer the latter than Saxen there was found a cavity about one yard in two dimensions, which was lined throughout with straw-coloured crystallizations of Stilbite. These occurred in huge crystals of sheafy arrangement about 8 inches in length by 5 in width. An attempt to extract it whole failed only at the last moment.

Tjornevig.—The mineral locality to which I have given this

Digitized by Google

name lies almost immediately opposite to the village of Eide in Osteröe.

Immediately facing the most promising landing-place there was found a druse some 9 or 10 feet in length, by about 2 in width and 1 in depth—resembling, in fact, the cavity of a slipper. One end, the toe of the slipper, had been laid open, so that the minerals which lined its inner surface were there, and for some distance inwards, defaced by a green deposit or growth. Upon being laid open the cavity afforded an ample supply of the two minerals, Heulandite and Scolecite. The Heulandite was of most unusual appearance. They showed only the faces *m t s b c*. The first three of these faces invariably presented themselves—and were almost of equal size. *b* was lengthy, from *m* to *m*, and *c* from *t* to *s*; so that the crystal assumed somewhat of the character of a prism *m c* with a termination *t m s*—or a superposition of crystals upon the face *a*.

Scolecite.—From the surface, or, it might almost be said, the summit of these crystals of Heulandite, there sprang in this cavity radiating brushes of crystals of "Needle stone" of extreme tenuity, transparency, and brilliancy. These brushes were over 2 inches in length, and where the sea had not penetrated to them, they were of great beauty. All were bound together at the extremity of the brushes by minute crystals of Stilbite, which lay as if dusted upon them.

The small cliffs which lie to the south-west of this spot are very scoriaceous or loose in structure. The vacuities are filled with radiating Faröelite to such an extent that one-half of the total weight of the rock must be due to that substance.

Along the shore to the south of this locality, and near to a stream about half way to Haldervig, the rocks contain a fair amount of Apophyllite. One specimen of this mineral here found was very much the finest got in the islands. It was, moreover, unique in the size and in the relative proportions of its faces. The crystals were from $\frac{1}{2}$ to about $\frac{7}{8}$ of an inch in each direction. The form was *p a e* and these faces were of nearly equal size. The usual specimens which are associated with Heulandite much resemble, both in proportion of their faces and in general appearance, the ordinary Icelandic type of the mineral. Large masses of crystalline Stilbite here obtained contained cavities lined with

Digitized by Google

delicate crystals of Scolecite, upon which were perched minute crystals of Stilbite.

Just as the hamlet of Haldervig comes in sight the rock becomes very wackenitic, and from it was wrenched a druse nearly a foot in one dimension, lined throughout with Scolecite. This from exposure was much weathered, but must originally have been of great beauty, as the termination of each crystal—these being two inches in length—was surmounted with a radiating and silvery-lustred coronet of Mesolite. Doubtless the tearing down of a quantity of the rock would be rewarded by the laying open of other druses.

Westmanshavnfiord.—The shore between Eilsness and Quivig yields occasional druses. From one there was obtained a singular and unique pseudomorph. It was not analysed, but appears to be Mesolite after Apophyllite. The colour is that of cream, and the combination *a c r* with occasionally a small *p*. When within about two miles of Quivig I found a flat druse—not more than a few inches in depth, but some 5 feet by 4 in its other dimensions—which was lined throughout with crystals of Heulandite the size of grains of rice, and of the usual combination *b c m t s*. On account of the dullness of the crystals and the absolute uniformity of their size they possessed little beauty.

A loose block of Moss-agate was found near Quivig of about 1 foot 9 inches by 1 foot. In some respects it was of unrivalled beauty. It was a portion of a vein of some 5 inches in thickness. The colour of the "Moss" or Celadonite which formed the cores of its innumerable stalactites was very poor—a pale straw; but the ramifications and intertwinings of these stalactites, and the internal lustre of the Chalcedony which formed them was unrivalled. When sectioned transversely to the vein some of the spaces between the stalactites were found to be filled with Onyx—the banding by Cacholong being so disposed as to show that the vein had been a horizontal one. Numerous small druses of red Wax Opal occur in this neighbourhood.

Waagoe, Midvaag.—The north shore of the bay inside of Sandevaag is cut by a vein of what appears to be white Saponite. The analysis of this was overlooked, probably from the indifference of its appearance.

Busdali Foss.—The rocks on each side of this waterfall—which

Digitized by Google

are somewhat precipitous—yield abundance of crystals of Stilbite, the chief feature of which is that in whatever form they take they somewhat overfill the druses in which they occur. *a b c* is the most commonly occurring combination; and a very fine specimen of *a b m c r* was also found. The crystals are of large size.

Sorvaagsfiord.—The shore-foot at both sides of the head of this fiord is abundantly studded with broken druses filled with radiating Scolecite. The specimens are dull and not fine.

Tindholm.—On the north shore of this island, and near the spot where a dangerous reef of rocks runs off to the north-west, Analcime occurs in crystals about 1 inch in size, which were much the finest I found in the islands, where this common zeolite is very rare.

This island is barred from its base to nearly its summit by successive deposits of Peat. One of these at the east end of the island, and at a height above the sea of about 100 feet, I observed to be studded with isolated white crystals, which on being extracted were found to be Heulandite of the combination *b c m s t.* They were fairly lustrous. This seeming to me to be an extraordinary mode of occurrence I examined the peat carefully. Its appearance was quite that of ordinary peat, only that it seemed denser; this the overlying 400 and odd feet of rock might well explain.

There is in the island of Graemsay in Orkney what more resembles a *vein* than a *bed* of peat of great density, the result, apparently, of a fault with an overslide at the spot.

I found there was sold in London a compressed peat for the lighting of fires.

I therefore analysed the three varieties as follows:—

	Graemsay.	Faröe.	London.
Sp. Gr. - -	1·31	1·27	1·2
Water - -	6·06	9·44	3·94
Volatile at 240°	6·88	4·16	6·29
Gas - - -	15·52	49·40	56·05
Carbon - -	·62	20·50	28·08
Ash - - -	70·92	16·50	5·64

There is thus nothing specifically anomalous in the composition of the Tindholm peat.

Digitized by Google

It is not conceivable that these crystals were formed after the usual mode of growth of zeolites, namely, by the endosmose of the material of decomposed plagioclase felspars into shut cavities, inasmuch as no such cavities here exist. The most reasonable explanation of their presence would appear to be that, during the growth of the plants which formed the peat, their roots had insinuated themselves into cavities of the decomposing surface of the sustaining rock, and the loosened crystals had been elevated by the upward growth.

Mygganaes.—I mention this island, not for its mineral wealth, for I found nothing worthy of note in the small part of it which I traversed, but on account of its containing the finest marine pot-hole which I ever saw. This is at, or rather forms, its landing-place; and it is somewhat doubtful if whether any one could land upon the island at any other spot, for if the pot-hole does not form the landing-place, it at least forms a dock in which boats can lie in safety at all times, except during a gale from the south.

The rock is one of only moderate hardness, and in some hollows of its surface fragments of basalt dykes have in far back times commenced, when swirled by the waves, to grind a circular cavity, which during the lapse of ages has been increased to its present dimensions—somewhere about 80 feet in length, nearly half as much in width, and perhaps three fathoms in depth. At its bottom are to be seen the numerous boulders which, during every gale from the south, must still be acting as pestles against its sides, which are everywhere undercut. As its eastern edge is within about a yard of an inlet of the sea, and the intervening rock only a few inches above its average height, boats can readily be hauled over and lie in safety. Filled at every tide it retains the water like a dock.

Hestöe.—The best part of the shore for minerals in this island is the south-west. The writer was, however, prevented by unfavourable weather from landing at that part, and was confined to the northern half of the east side. There is a brilliancy about the zeolites of Hestöe which is above that of other localities in Faröe, and most of the druses have a Celadonite skin—not seen elsewhere in the islands. Hestöe is the only locality for that violet-coloured variety of Calcite which resembles Chalcedony, and is called Brunnerite. It occurs in

Digitized by Google

very squat rhombs, but the form of these, from the roughness of their faces, cannot be accurately determined. It is disposed generally in isolated crystals, but also in clusters, on the summits of crystals of Apophyllite.

The Apophyllite of Hestöe is the most brilliant and pellucid in the islands, probably in the world. It occurs colourless, pink, and green; all are pellucid, and it is generally unassociated with any other mineral, except the above-mentioned variety of Calcite. Its combinations are *p*, *ap*, *a p c*, *a p r*.

Heulandite.—This occurs in two varieties. The first is in somewhat large crystals of a fine pink colour, which form the bases of druses of Apophyllite. Their form is the usual one. In the second variety the crystals are small, not half of the size of rice-grains, but of extreme brilliance, and stand isolated and almost unattached on the surface of their matrices. Their combinations are *b s t*, *b s t c*. The lustre of *b* is very high.

Along the whole of this portion of the shore of the island, and also along its northern shore, druses about the size of a closed fist occur; these have a skin of Celadonite, and are lined throughout with a continuous sheathing of crystals of Analcime of a pale blue tint. These crystals, which have a high polish, are of uniform size—hardly that of a small marble. They are occasionally penetrated by delicate acicular crystals of Scolecite, so as to form an interesting combination. They present no other than the usual form.

[Owing to the regretted death of the author before this paper was printed, the proofs have not received the benefit of his supervision. Fortunately, however, Mr. Goodchild, F.G.S., who has lately (1901) edited Dr. Heddle's "Mineralogy of Scotland" in two fine volumes, undertook to read the proofs and to re-draw the author's sketches of the crystalline forms (reproduced on page 7). Ed. 1902.]

Digitized by Google

No. II.—The Lower Carboniferous Rocks of Northern Britain. By Mr. Goodchild, F.G.S., F.Z.S., of the Geological Survey, Curator of the Scottish Geological Collection in the Museum of Science and Art, Edinburgh. With two Diagrams and a Section [Plate I.].

[Read 11th October, 1900.]

Introduction.

Between the summer of 1867 and the close of 1879 I was almost continuously engaged with Professor Hughes upon the Geological Survey of the Dales of North-west Yorkshire, and the adjacent parts of North Lancashire and East Westmoreland. This district embraces the whole of the typical Yoredale area. In the course of this work I made detailed measurements of almost every section exposed, and plotted over 72,000 feet of these, on a uniform scale of 40 feet to an inch. I also had the advantage of studying the Lower Carboniferous Rocks of the northern half of Westmoreland, and much of both Northern and North-western Cumberland, as well as of some parts of Northumberland adjoining Roxburghshire. Lastly, during a residence of thirteen years in Edinburgh, a large part of my time, when not engaged officially, has been occupied with the study, in the field, of the Lower Carboniferous Rocks of Scotland. In this part of my work I have gained much knowledge from a study of the publications of the Geological Survey, and have especially learned much that is of value from the writings of Mr. H. M. Cadell and Mr. W. Gunn, F.G.S., on the geology of the east side of Scotland, and from those of the late Dr. John Young, F.G.S., and other geologists of the west country, for that side of Scotland. Mr. John Henderson's writings on the Lothians have also given me much help; and I have to thank my colleague, Mr. Macconochie, for many friendly hints. On the geology of the Lower Carboniferous Rocks of the English Borders my chief information has been gained from the publications with which are associated the names of my colleagues, Messrs. Gunn, Clough, and Hugh Miller, so far as concerns Northumberland. Again, no one can study the geology of North Lancashire without constant reference to the numerous

Digitized by Google

and important papers on its Lower Carboniferous Rocks by Mr. Tiddeman, which have been my constant guides on several visits to Clitheroe.

THE PHYSICAL GEOGRAPHY OF LOWER CARBONIFEROUS TIMES.

I. The chief point for consideration under this head is the configuration of the surface upon which these rocks were laid down. It may appear, at first sight, an easy matter to deal with, as all that seems to be needed to supply the data from which the required conclusions may be drawn is to plot a series of sections representing the known successions and thicknesses of the strata below the datum selected for the purpose, and from these mere inspection would suffice to show where the ancient hills and hollows were situated over the area represented by the sections in question. This method, however, would afford results which would be by no means trustworthy in all cases; for unequal or differential subsidence is always a factor of great importance in the present connection. We also have to take into account the possible occurrence of abrupt changes of thickness which may arise from differential subsidence on either side of zones of older faults, which has long been inferred to have been the case in Craven. A further cause of variations in thickness is connected with proximity or otherwise to centres of volcanic action.

Still, after making due allowance for possibilities, there often remains perfectly clear evidence of many original inequalities of the floor upon which the rocks under consideration were laid down. Some of these were so considerable that they were not entirely effaced by being levelled up until late in Carboniferous times.

One of the first requisites for the determination of the position and extent of these old inequalities is the choice of a suitable datum, from which a succession of downward measurements of thickness can be safely made. The datum selected should be one definite bed of rock, which can be shown by its fossils, its mineral character, or by satisfactory evidence obtained on the field, to be one and the same bed; and it should be one that can be proved to extend over a wide area. Now that Mr. Gunn has identified the lowest limestone of Dunbar with the Eelwell Limestone of Northumberland (and consequently with the Five-Yard Limestone of

Digitized by Google

East Westmoreland), we have means of correlating the Hurlet Limestone over an area which cannot be less than twenty thousand square miles, and may be considerably even more than that. Hence, however much the petrographical characters of the beds below that horizon in various districts may differ, we are on perfectly safe ground when we take our stand upon this platform in any attempt at reviewing the form of the surface on which the basal members of the Lower Carboniferous Rocks may lie in any given district.

It is on that principle that the horizon of the Hurlet Limestone has been chosen as the datum line in the series of comparative sections which accompany this paper. (See Plate I.)

We encounter some difficulty in making a survey of this kind, inasmuch as there are large areas over which the Lower Carboniferous Rocks which were formerly present have been removed by denudation; while, in other areas, even where the datum bed is left, we have not always the means of determining the depth of the base below that platform. The chief areas where the conditions are most favourable for the purpose here in view, are (1) the belt of country adjacent to the Craven and Pennine Faults; (2) the areas fringing the Lake District; (3) Liddesdale; (4) Tweedside; (5) the Berwickshire Coast; (6) the basin of the Forth; (7) the Clyde area, including Arran and the coasts of Carrick and Galloway.

There is little need to go over the details of the sections in these respective areas in an address of this nature, which is intended to deal only with the broader features under consideration, for the main points are sufficiently indicated in the sections appended to this paper. Still, attention may be directed to some of the most striking evidences of inequality. If we take the evidence of the Craven area, in the neighbourhood of Clitheroe, we find there a thickness of some thousands of feet of Lower Carboniferous Rocks, without the base being reached; while in the areas around Ingleborough, not many miles to the north, the total thickness hardly amounts to one-fifth of that. The Craven Faults occur between the two areas, and Mr. Tiddeman lays great emphasis upon the possibility (in which many geologists will probably agree with him) that the Craven Faults, which are known to date back to pre-Car-

Digitized by Google

boniferous times, may have formed a zone on either side of which an unequal subsidence occurred while the Lower Carboniferous Rocks were in process of deposition. On the other hand, it might be urged (as I pointed out in the early "seventies" when this question was first mooted) that there may be some other factor concerned in bringing about the disparity in question, inasmuch as local variations in thickness on even a larger scale can be shown to occur within an area entirely on one side of the lines of fault referred to. For example the total thickness of the Mountain Limestone on the eastern side of the Basin of the River Lune in the zone adjacent to the Great Faults (as, for example, at Garsdale and other places in North-west Yorkshire), is nearly four times that seen under Ingleborough, although the distance between the two sections under comparison is only about half of that between Ingleborough and Clitheroe.

In dealing with the correlation of the Yoredale Rocks in the area north of the Craven Faults with those around Clitheroe, the difference in thickness, as may be seen on comparing the sections, is very much more marked, and can be much more easily accounted for by the explanation advocated by Mr. Tiddeman. There are, even in this case, further causes of perplexity in attempting the correlation, as I have long held (and have, for many years past, often pointed out to others) that the higher beds of the Mountain Limestone of Clitheroe are probably of the same age as the lower part of the Yoredale Rocks of the typical area; while the higher beds above the Pendleside Limestone may represent Yoredale strata which are absent in the country to the north, in consequence of an unconformity at the base of the Upper Carboniferous Rocks. This will fall to be discussed at greater length farther on. The general conclusion to be drawn from the facts in the present is that part of the inequality of thickness is due to original unevenness of the sea-floor, and part of it to differential subsidence.

Around the English Lake District some very interesting phenomena may be observed, which have an important bearing upon the questions at present under consideration. On the southern and south-eastern side of the Lake District the Mountain Limestone retains its normal character and thickness with but little change, and the same may be said of the Yoredale

Digitized by Google

Rocks. But as we advance northward, on the eastern half of Westmoreland, the almost-undivided limestones of the Mountain Limestone gradually give place, first, to alternations of limestone and shale, and then later to beds of sandstone, or even of conglomerate; so that, under Roman Fell, as I pointed out in 1874,* beds of clastic origin predominate, and foreshadow, as I then stated, the advent of the so-called Calciferous Sandstones.†

CHANGES OF PETROGRAPHICAL CHARACTER.

II. The general nature of the change that arises as the beds trend from south to north is that the various calcareous members disappear and give place to sandstones and shales one after the other, beginning with the lowest, and so on in succession upward. The lowest limestones thus disappear farthest south, and the highest range farthest north. The rate of thinning of the limestone can be easily measured in some parts, and works out to about one foot in fifty in the case of the lowest beds. This rate appears to diminish rapidly in the case of the higher beds, and, in the case of the upper half of the Yoredale Rocks, is practically nil between Yorkshire and the basin of the Forth and Clyde.

Followed north-westward from the eastern side of the Lake District the Lower Carboniferous Rocks are found to undergo a different kind of change. When the several members of the series are traced in this direction, say from Appleby to Whitehaven, each of the limestones lowest in succession at any given spot gradually thins away, and the next above disappear, one after the other; while in this case rocks of detrital origin do not uniformly occupy their place, as they do along the lines from south to north. As a consequence of this peculiar change, nearly the whole of the Mountain Limestone gradually thins away, and only its higher members, probably not more than about a hundred feet in total thickness, are left in West Cumberland. In accordance with the law just stated, the Yoredale Limestones, being subject to no such

* *Quart. Journ. Geol. Soc.*

† It may be remarked here that these Calciferous Sandstones appear to have been so named on the *lucus a non lucendo* principle, seeing that calcareous matter is usually conspicuous by its absence; just as is the case with the so-called Cement-stones, which rarely contain any kind of stone likely to be of practical use in the manufacture of cement.

Digitized by Google

diminution in thickness, persist throughout, while the sandstones and shales, which form nearly four-fifths of the subdivision in eastern Cumberland, steadily decline in thickness until they disappear entirely, and the lower half of the Yoredale Rocks coalesces as one almost-undivided mass of limestone with the remnant of the Mountain Limestone before mentioned. (I may remark here that an official report embodying this statement was formally sent by me in 1872 to the then Director of the Geological Survey, the late Mr. Bristow; but as the same conclusions were freely communicated both by letter and by word of mouth to other geologists before they were published, the usual result ensued.) Briefly summarised, the facts are simply these —that the so-called Mountain Limestone of the Whitehaven district represents the lower half of the Yoredale Rocks—the upper half being called "Millstone Grit and Lower Coal Measures." To this latter point reference will be made again. (See the diagram section on page 25.)

North-eastward from Whitehaven and Maryport, where this type occurs, there intervenes a space of about forty miles in which the Carboniferous Rocks are entirely concealed beneath newer strata; and it is not until we advance well into the basins of the Liddle and the Esk that we have again an opportunity of making any comparisons of the nature here under consideration. Here, however, the rocks are on the whole fairly well exposed, and although they are greatly disturbed by faults and folds, and their continuity is much interrupted by denudation, it is quite possible to make out the succession. Briefly stated, the rocks may be described as of the characteristic Scottish type. At the base occurs the Upper Old Red Sandstone—of course, very variable in thickness. This passes up into a mass of sandstone which corresponds fairly well with the Cornstones type of rock usually found in this horizon. Then (ignoring the volcanic rocks for the present) follows a thick mass of more or less calcareous shales, locally presenting tints of dull chocolate and greyish green. Interstratified in the higher parts of these shales (which I regard as the Ballagan Beds) occur irregular and very impersistent bands of argillaceous limestone, which contain, amongst other fossils, *Mitcheldeania* in fair abundance. This (supposed hydrozoan) is not known to occur in any higher geological horizon than

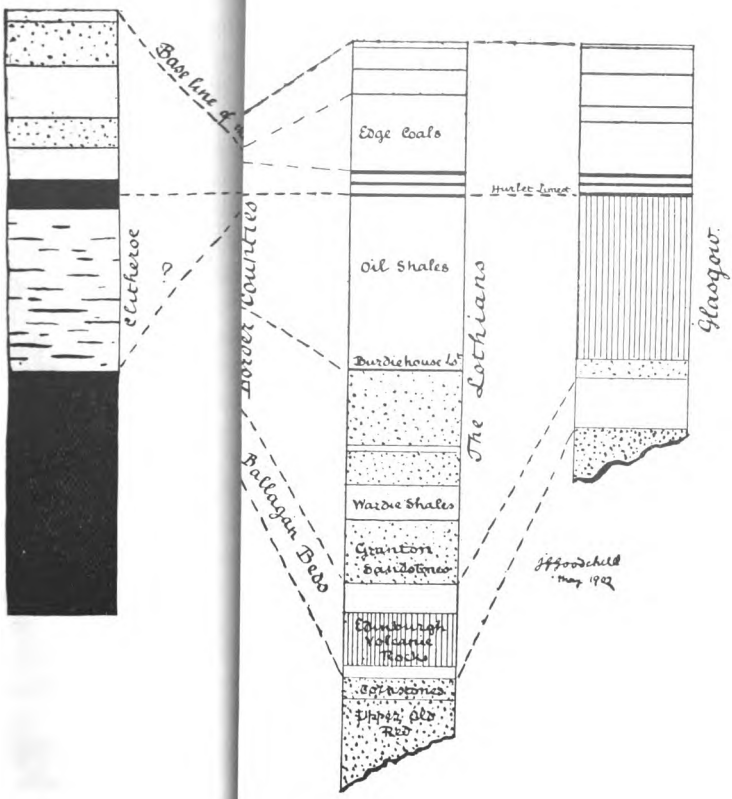
Digitized by Google

the Lower Limestone Shales, the true d^1 of the Geological Survey. In the higher part of these Liddesdale shales occurs the celebrated fossiliferous horizon of Tarras Water Foot, discovered by Mr. Macconochie, and from which he and others have obtained so large a suite of fossils—amongst which are the remarkable fishes described by Dr. Traquair. (*Trans. Roy. Soc. Edin.*, xxx.) Near their highest bands the Ballagan Beds graduate upwards here into the Fell Sandstones, a group of more or less massive sandstones, with which are interstratified some subordinate bands of shale and some few very sandy limestones or calcareous sandstones ("Kingle Beds") which usually weather of an ochreous tint, as if they contained (which they probably do) some carbonate of iron as well as of lime. These Fell Sandstones are about six hundred feet in thickness. Still ignoring any volcanic rocks, as being, so to speak, adventitious, and of no direct account in the present connection, we find the Fell Sandstones graduating upwards into a series of alternations of sandstones and shales with some few workable coals. It is in these that the Plashetts Coals occur. This subdivision, in turn, passes upwards into the next, which includes several bands of marine limestone, and but few coal-seams of any great value. Finally, so far as we are concerned in the present enquiry, comes a group of strata containing beds of well-marked grey limestone, which have long been known to pertain to the lower half of the Yoredale Rocks, and which include amongst them the equivalent of the Hurlet Limestone. The reader desirous of further information upon the correlation and the local names of these beds cannot do better than consult Mr. Gunn's paper before referred to. (See also Plate I.)

Mr. Macconochie tells me that the Glencartholm Fish-bed, from which he obtained so many fossils of interest, occurs on a horizon not far above the top of the Fell Sandstones. The position of these two important fossiliferous horizons of Liddesdale will be found indicated upon the section accompanying this paper. (Plate I.)

The chief points of interest to students of Scottish Lower Carboniferous Rocks, therefore, centres in the study of the four types within the basin of the Solway. These are—(1) The East Westmoreland Type, (2) the North Westmoreland Type, (3) the West Cumberland Type, and, lastly, (4) the North Cumberland

Digitized by Google



inburgh and Glasgow.

Digitized by Google

Digitized by Google

Type. If the inter-relations of these are understood, those of all the others can be likewise understood without much difficulty. I do not propose to discuss types 1 and 2 further than to remark again (what I pointed out in the paper published in the *Q.J.G.S.* in 1874) that the so-called "Calciferous Sandstones" of Scotland are mainly the horizontal equivalents of the lower two-thirds of the Mountain Limestone of the North of England, and that they are not, as has been stated in official publications, the equivalent of the Lower Limestone Shale (d^1 of the Survey). This latter, as I have repeatedly stated, is represented in Scotland by the Ballagan Beds (in the middle of which occur the volcanic rocks of Arthur's Seat and the Calton Hill, &c.).

At least an equal degree of interest lies in the discussion of the reason why there is so marked a discrepancy in thickness, in mineral character, and in fossil contents, between (3) the West Cumberland type and (4) that found in the northern part of the same county.

In making the comparison, attention may be called first of all to the sections given below and those at the end of the paper. (Plate I.) A glance will suffice to show that the whole of the beds below the main calcareous horizon in No. 4 are absent in West Cumberland. This being the case, the question arises whether what is now the Lake District, or any part of it, remained as dry land until a late period in Lower Carboniferous times. The most commonly-received view is that it did so remain as an upland area, and was never covered by the sea during Lower Carboniferous times. But, like a great many more views that are generally accepted (and, as such, have found their way into text-books), this has been adopted without either proper consideration or full knowledge of the facts. Two or three of these facts will suffice to indicate the inadequacy of this explanation. Firstly, the dip of the Carboniferous Rocks of West Cumberland is everywhere in excess of the slope of the rock-surface from which they have recently been denuded. (This, by the way, is true for the whole of the Lake District.) In other words, if it were possible to level out the Lower Carboniferous strata which fringe the Lake District the whole of the *massif* would everywhere be carried deep below the sea-level. Secondly, the rocks which form the lower members of the Carboniferous Series in West Cumberland

Digitized by Google

are mostly pure grey limestones, which were manifestly accumulated in clear water (in *deep* water, I think) and far removed from any source of detrital material. None of them show the slightest resemblance to any coral reefs; but all are, on the contrary, not only very evenly-bedded, but they show very regular and often fine lamination as well, and in no essential respect do they differ from the deep-sea calcareous oozes of the present day. On the other hand, their equivalents in Liddesdale consist almost as much of material of clastic origin as of limestone. Thirdly, the south, north, and east sides of the Lake District show a full development of rocks of clear water origin, and of the normal thickness, as I have endeavoured to show. So, it seems to me, as I have often stated in print, that there is absolutely no foundation for the view that the English Lake District is an old fossil island re-exposed by denudation. What comes to the same thing is that there is no evidence of any overlap of any of the North of England limestones in the direction of the Lake District; though, as I have pointed out, there is much evidence in other directions. We are therefore obliged to seek for some other explanation of the fact that the lowest beds of the Carboniferous rocks in West Cumberland belong to the middle sub-division of the Lower Carboniferous.

We may gain some insight into the relationship of the Border type of Lower Carboniferous Rocks to those of West Cumberland by reference to the following diagram. Confining attention to the rocks specially under consideration, we see, in reference to the figure, that a rapid attenuation takes place below the Solway, and where the rocks of Liddesdale emerge on the flanks of the Lake District they have not a tenth of the thickness they show on the Scottish side. On the other hand, the Scottish type consists almost entirely of rocks of detrital origin, and were evidently formed in a delta; while their equivalents on the English side are almost entirely thalassic, and show no signs of any proximity of land. If we follow the outcrops of the Lower Carboniferous Rocks outward from Liddesdale along the north shores of the Solway the evidence of the gradual attenuation of the several members of the series in that direction comes out clearly enough. I should remark here that I am again indebted to my colleague Mr. Macconochie for help in this part

Digitized by Google

of the enquiry, and I have much pleasure also in mentioning the assistance given me by Mr. Ernest Gibson and his sisters, who have done good work in collecting the fossils from the north shores of the Solway, and who have placed the materials in my hands for the present purpose.

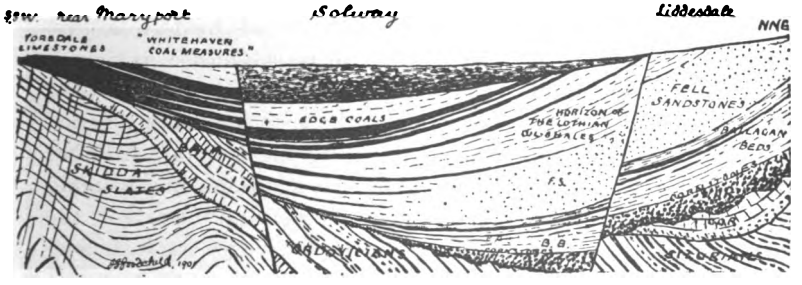


Diagram 1.—Section across the Solway from West Cumberland to Dumfriesshire, a distance of about forty miles. Not drawn to scale. The beds drawn in black are limestones. The section illustrates the nature of the changes from the West Cumberland type of Lower Carboniferous Rocks to the type prevailing in Scotland.

If this kind of relationship of the one type of strata to the other were simply confined to the area now specially under consideration it might be regarded as an accidental circumstance, and be explained, or not explained, according as to how the matter happened to be regarded. However, it does not stand alone, but is only one instance out of many of the same kind. We must therefore seek for some explanation which can be applied to all the cases, and accordingly I propose to suggest the following as a possible solution of the problem :—

It must be premised that there is proof that the land from which the materials of the Lower Carboniferous Rocks under notice were derived came from an old continental area lying to the north-west, and also that the deeper-water parts of the sea lay chiefly to the south-east of this area. Hence a larger proportion of terrigenous material may be expected to be met with as we advance from the seaward fringe of the old delta towards its head. Now, to explain the facts that are observable in many deltas, ancient as well as modern, I wish it to be granted that it may be possible that all deltas accumulate over zones of subsidence, and that the subsidences in question affect an area of but limited

Digitized by Google

horizontal extent transversely to the axis of the delta, while in the direction of that axis the area affected may be much more extensive. In other words, the areas of subsidence form long troughs. Corresponding trough-like depressions of the surface are also slowly developed over the axes of the down-folds. Under these conditions, it is quite clear that any river channel near the axis of folding would be led, by degrees, into coincidence with that axis. Hence, where subsidence was going on at the highest rate, there also would take place the deposition of the largest quantity of the rock-material which was held in suspension or was drifted along the bottom. In other words, the area of most rapid subsidence, and those of most rapid deposition of clastic material, would coincide, and the axis of the delta would coincide with the axis of depression. Seaward from the margin of the delta the layers of sediment would be found, when traced outward from the land, to pass from gravel to sand, from sand to clay, from clay to coal, from coal to impure limestone, and from impure limestone to the pure calcareous ooze of thalassic areas. Each of these would form one of a series of crescentic zones with the concave side turned towards the land, each zone, in succession, from the land outward, being thinner than the other. (See Diagram No. 2, on next page.)

If this hypothesis be granted as at least possible, it will not be found difficult to make use of it as an explanation to account for the phenomena specially under consideration. According to this view, the area represented by the basin of the Solway lay on the south-west side of the principal axis of subsidence, and while the areas nearer the axis were carried down at a slightly more rapid rate than those at the sides, yet deeper and clearer water was maintained in the areas farther from the axis, because the chief deposit of sediments took place in the neighbourhood of the axis. The axis of depression during Lower Carboniferous times in North Britain may have ranged in a south-south-easterly direction, say, through Perth, Edinburgh, Selkirk, and Hexham. I do not know at present of a single fact that tells against this view, while many facts otherwise inexplicable seem to me to readily meet with an explanation on this view of the matter. It will be seen that local inequalities, islands, shoals, and other such features may have existed, and

Digitized by Google

doubtless did. One of the most remarkable of these is the case of the areas in Fife near Loch Leven, where the Upper Old Red Sandstone forms a sloping bank against which the Lower Carboniferous Rocks of the Forth area become thinner, and overlap each other in succession from below upwards, until, at the part named, the middle of the Yoredale Rocks lies almost directly upon the Old Red. A similar case occurs near St. Andrews, where beds equivalent to the Oil Shale Series lie directly upon the Cornstones of the Upper Old Red. And there are other cases of the same kind at several places around the head-waters of the Clyde, and again in Western Galloway. But the explanation just given is in no way invalidated by such facts. All that I want to explain is readily enough done if we assume that while the main axis (or axes) of subsidence during Lower Carboniferous times lay over the south-east of Scotland and the north-east of England, the deposits on the west, from the basin of the Clyde to the basin of the Solway, formed part of the south-western limb of the crescents of deposit exterior to the delta proper. Hence the relatively-small proportion of sediment and the relatively-large percentage of limestones as we trace the succession from east to west. The annexed diagram may help to make this more clear.

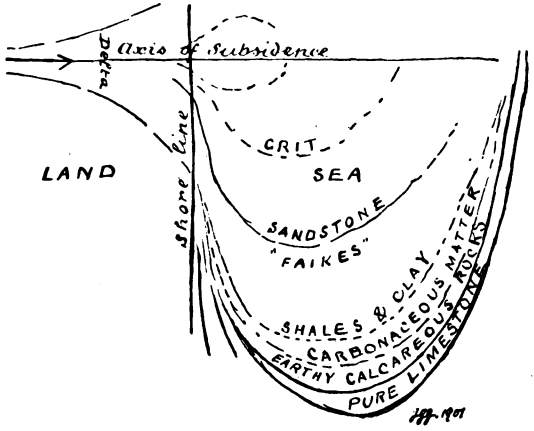


Diagram 2.—Crescentic Zones of Subsidence (see page 26).

The depths below the horizon of the Hurlet Limestone in different localities, therefore, are in some cases determined by

Digitized by Google

original inequalities of the surface which afterwards became the sea-bottom, partly to inequalities of subsidence, and partly to differences in the nature and the thickness of the material laid down.

There is yet another factor in connection with local variations in the thickness of rocks, and that is proximity to areas where volcanic action has been rife. The curious and interesting fact of the central subsidence so often traceable in connection with volcanoes is by no means confined to their immediate vicinity, but may affect areas around to an extent of several miles in each direction. Regarding the explanation of the cause or causes to which these central subsidences are due I need not here offer any suggestion.

As the object in view in delivering this address is not so much to present details as to discuss some of the larger problems connected with the subject, it may be as well now to leave the comparative sections to speak for themselves, and to pass on to the discussion of some other matters about which more or less uncertainty still appears to exist. Amongst these a few sentences may be devoted to the origin of some of the constituent members which go to make up the Lower Carboniferous Rocks. And if, in putting forward my own views (or what some rather backward persons are pleased to describe as my heresies), I do not always express those which are current amongst my fellow-workers, I do so because it seems to me to be always conducive to the advancement of science if we now and then review old questions from new standpoints. It may often prove that the older views are preferable. On the other hand, it may quite as often turn out that these older views are no longer tenable. Anyway, some good is gained, and even when a new theory has to be consigned to the limbo of oblivion, the successive steps in the investigations which have led to that judgment have rarely proved to be quite devoid of edification to those who have taken part in them.

As one of the questions involved concerns the origin of coal, I may as well here state that I hold with those who regard coal as a subaqueous deposit* formed from macerated vegetable matter

* See *Geol. Mag.*, July, 1889; *The Colliery Guardian*, May, 1889; *Proc. Royal Phys. Soc.*, 1888-9, pp. 97-100.

Digitized by Google

of various kinds, sorted by rivers, stratified by the agency of sea-water, in one of the crescents around a delta, and afterwards reduced in part to a resinous condition by the action of the sulphates present in the sea-water.

The allied constituents of the Lower Carboniferous Rocks, the Oil Shales, are, I think, also due to the action of sulphates in solution in lagoons upon the macerated vegetable matter drifted therein from the land.*

As regards the origin of the limestones, I need not do more here than emphatically express my dissent from the views of those who regard those of Lower Carboniferous age as in any way connected with coral reefs. If there were no other objection to this view than the fact that the reef-building habit amongst corals did not come in until late Tertiary times, that would be sufficient. But all the Lower Carboniferous Limestones are unquestionably stratified deposits, usually, also, very finely laminated; and their constituents are almost exactly analogous with those of the recent foraminiferal oozes, in which a large proportion of the rock consists of amorphous carbonate of lime due to the reducing action of organic excreta and dead organic matter of various kinds upon the sulphate of lime in sea-water.

I may remark here, as elsewhere, that the Burdiehouse Limestone consists of a stratified mixture of bituminoids (due to the action of sulphate of lime upon vegetable matter), and chemically precipitated carbonate of lime. This latter is probably due to the cross re-action of decomposing organic matter upon the solutions of sulphate of lime present in the concentrated waters of the lagoon in which this rock was formed.† The limestone in question is often simply a mixture of oil shale and pellets of chemically-deposited carbonate of lime.‡

I have intentionally omitted more than a passing reference to the important share that volcanic matter takes in the building of the Lower Carboniferous Rocks in Scotland. This has been done, partly because that aspect of the subject could not be adequately dealt with in an Address like this. Partly, also, it has been left

* This view was put forward in the *Trans. Geol. Soc. Edin.*, vol. vii., 1895, "On the Modes of Origin of some Oil Shales."

† See *Geol. Mag.*, III., vol. vi., p. 314, "The Formation of Coal-seams;" and III., vol. vii., p. 73, "The Paste of Limestones."

‡ *Trans. Edin. Geol. Soc.*, vol. vii., part 3, p. 130.

Digitized by Google

out, because an undue share of attention is just at present being devoted to lithology, to the exclusion of matters of at least equal interest. But it may be remarked here that volcanic rocks of Lower Carboniferous age are, singularly enough, hardly found anywhere on the English side of the Border, except in Derbyshire; while they set in in full force within, literally, a few hundred yards on this side of the arbitrary line that politically divides England from its sister kingdom.

No geologist seems to have yet published any statement regarding the petrographical characters and the respective thicknesses of the various subdivisions of the Lower Carboniferous Sedimentary Rocks, *as a whole*, in the West of Scotland. Even the measurement of the Arran sections does not seem to have yet been attempted, or, if it has been, we have as yet no means of obtaining a conspectus of the whole; nor has it been done in Ayrshire. It is a matter of some importance to know what were the sedimentary rocks which were being deposited at various points in the West of Scotland while the volcanoes were in action within the Clyde Basin.

Another point is as to how much importance should be attached to mere colour. It seems to have been the fashion for many years to regard any post-Devonian red rocks as either "Permian" (whatever that may mean), or else as being high up in the Carboniferous Series. I have steadily maintained the view for the last ten years that there are absolutely no "Permian" rocks (*i.e.*, Lower New Red or Dyas) anywhere in Britain north of Cumberland. Even the Arran rocks formerly referred to the Upper Old Red are now generally recognised as Trias.*

I have also maintained since 1869 that a large part of the post-Devonian and pre-Triassic sandstones of a reddish colour are nothing more than ordinary Carboniferous Sandstones which did not happen to contain carbonaceous matter, and had been formerly covered by the New Red. It was from the old lakes in which parts of the New Red were formed that these rocks received the ferruginous solutions to which their present colour is due. It is a curious illustration of the reluctance of many persons to consider

* I formally called the attention of the Director of the Survey to the existence in Arran of the Bunter, the Waterstones, and the Keuper Marl some years ago.

Digitized by Google

a new view that, to this day, many geologists, of whose ability no one has any doubt, still persist in regarding these red-stained rocks as something stratigraphically different from the Carboniferous. We still hear of the "Fife Red Measures," of the "Uddingston Permian," and so on.

The remaining point to which I specially desire to call attention in this Address relates to the Life of the Carboniferous Period. In making any remarks upon this part of the subject before an audience of Glasgow geologists, I find myself differently circumstanced from what I should be when speaking on palæontological questions before my fellow-workers in Edinburgh. Most of these, unfortunately, have not yet got so far as to take much interest in the Life of the Past. At present they seem never so happy as when they have got an excuse for giving currency to some uncouth name which has been bestowed upon some one of the infinite variety of bits of stone they may pick up; and they are all for the lifeless side of geology. A Glasgow geologist, as a rule, will devote his energies more to collecting and studying fossils. Tastes differ. My own would lead me to regard matters pertaining to palæontology as of infinitely greater interest than mere species-work in lithology; and I should certainly hail any discovery with the liveliest satisfaction if it would enable us in any way to gain a better understanding of the relationship between the Life of the Past and that of the Present. I should also rank the knowledge so gained at a much higher value than a knowledge of the difference between a dolerite and a diabase, or that between a basalt and a melaphyre.

But, returning to the subject specially under consideration, we find that one question connected with the palæontology of the Carboniferous Rocks relates to the very remarkable absence of any well-marked and distinctive life-zones in either of their two subdivisions. It has, of course, long been perceived that the fossils of the Upper Carboniferous Rocks were different, as a whole, from those of the Lower. The researches of Dr. Traquair amongst the fish and of Mr. Kidston amongst the plants have now amply confirmed this view, and have placed the fact beyond the possibility of a doubt. There yet remains for consideration, however, the question whether what is true of these major divisions will apply equally to the various subdivisions of each.

Digitized by Google

The question, in other words, is whether life-zones similar to those of the Jurassic Rocks or of the graptolitiferous beds of the Ordovician and Silurian Rocks are to be found in the rocks of Carboniferous age. So far, the answer has been in the negative. Now and then, it is true, one fossil or another has been singled out as distinctive of some particular platform; but on making comparisons over a larger area the evidence has nearly always tended to show that the rule did not hold good. I have been in search of such life-zones for the greater part of my Survey life; but from 1867 to the present day I have been unable to prove their existence. Others may be more fortunate; but until that has happened, we must assume that they do not exist, or, at any rate, that there is no evidence of any such limited vertical distribution of species within the Carboniferous Rocks as could be in any way paralleled with the distribution of the Ammonites in the Older Neozoic Rocks or with that of the Graptolites in those of the Proterozoic systems.

To realise the true nature of the inquiry before us, it is as well to make a comparison between the geology of the Jurassic Rocks (which were formed under much the same conditions as the Carboniferous) and that of the rocks specially under notice.

The Jurassic Rocks, all told, may locally attain to a thickness of about three thousand feet. The Lower Carboniferous Rocks near Edinburgh are nearly four times that thickness. Both sets of rocks are chiefly of marine origin, with some estuarine bands, and, possibly, here and there a deposit of freshwater origin. Both consist of alternations of argillaceous, arenaceous, and calcareous members, which occur, in both groups of strata, in the successional order stated. Both were formed under genial conditions of climate, and both commenced at the close of a period of desert conditions, and terminated by continental (as distinguished from marine) conditions. So the comparison between the two is a very just and suitable one.

When we examine the fossils of the Jurassic Rocks, we find, as almost every school-boy knows to-day, that there is a very remarkable zoning traceable. A thickness of only a few feet, or even inches of strata, is often sufficient to mark off one set of fossils from those found in the beds immediately above and below it. And when the fossil contents of beds farther apart are com-

Digitized by Google

pared the difference becomes still more marked. And this holds good from top to bottom of the whole series. Moreover, the phenomenon is by no means confined to one restricted locality, but it may be traced in like manner over many thousands of square miles.

Thus, as William Smith long ago pointed out, it is possible to identify strata in areas far removed from each other by means of their included organic remains alone. After allowing for the exaggerated estimates of the value of this kind of evidence which have occasionally been made by men of narrow views, there still remains a very substantial basis of fact upon which the principle of the zonal distribution of fossils has in this case been founded.

If now, before turning to the Carboniferous Rocks, we examine various other groups of strata, such as the Chalk, we find that the same principle holds good, although not quite to the same extent.

Going to the other end of the geological scale, we all know now how the threefold division of the Cambrian Rocks by means of the Olenellus Group, the Paradoxides Group, and the Olenus Group holds good over so large an area of the earth's surface.

Finally, we may take the Graptolite zones of the Ordovician and Silurian Rocks, which present us with illustrative examples even more remarkable than those of the Lias. Thanks mainly to Professor Lapworth's researches, we are now able to "zone" the Ordovician Rocks, and also those of Silurian age, most unerringly, by the aid of their Graptolites. And some of the zones in the black mudstones may not exceed more than even a few inches in thickness.

Knowing these facts, it is hardly to be wondered at that so many geologists have held out to themselves hopes of being able to make out life-zones in the Lower Carboniferous Rocks. So far, as just remarked, all attempts at doing so have proved complete failures. Hence we may well ask ourselves why it is that one set of strata should show a definite set of fossils peculiar to each zone of a few feet in thickness, while another set, formed under what would appear to be precisely the same conditions, show absolutely no trace of any such restricted vertical distribution of its fossils.

The disparity can hardly be due to differences of physical conditions connected with deposition, because the same alterna-

Digitized by Google

tions of argillaceous, arenaceous, and calcareous components occur equally in the Jurassic Rocks and in those of Lower Carboniferous age. It cannot well be due solely to equability of climate in either case, because the climate appears to have been as equable during Jurassic times as was that of Lower Carboniferous times. One might speculate again and again upon the causes that determined the rapid replacement of species in the one, and the reverse in the other, without getting nearer a solution of the difficulty.

One of the chief objects before me in giving this Address was to attempt an answer to this question. The explanation I have to give is, I believe, quite a new one, or, if it has been advanced before by any one else it has been done without my knowing of it.

To understand this explanation a few preliminary remarks are necessary :—

The causes that determine the survival, or the extermination, of any given species of animal or plant, are, as is well known, of a highly complex nature, and such that they cannot be adequately stated in anything short of a treatise of considerable length. Nevertheless, there are some few broad principles which, in an enquiry like the present one, it is possible to enunciate within a few sentences. The factor of primary importance in the changes which affect both the animal and the vegetable kingdoms is undoubtedly that of time. But changes of environment may accelerate or retard the rate at which these secular changes of life are brought about. Amongst the factors connected with environment changes of climate are, in many respects, the most important. On the whole it would probably be safe to state that Plants respond to such changes more rapidly than Animals; and thus the general nature of their fossil remains may be taken to indicate the climatal conditions prevalent where they lived. It is from a consideration of the general features connected with the vegetation of Carboniferous times that our forefathers drew the now-familiar conclusion that the climate under which those plants flourished was both mild and equable. If, along with that conclusion, our predecessors also came to believe that there was a higher percentage of carbon dioxide in the atmosphere than there is now one can hardly wonder at the mistake, considering the state of knowledge at the time.

Digitized by Google

When animals are considered in relation to climate the case is somewhat different, because most of them can adapt themselves more easily than plants can do to changes of that nature by migration, or by other means.

It is with marine invertebrata, however, that we are now more especially concerned. Of the many facts connected with their life-history perhaps the most important are those which concern the earlier stages of their existence. It is apt to be forgotten that most marine invertebrata, whether fixed or locomotive, or whether they live in the adult condition on the shore, at the bottom, or in the open sea, spend the earlier parts of their lives as free-swimming organisms, whose habitat is mostly confined to a small depth below the surface. This is true of most Mollusca, Arthropoda, Brachiopoda, Polyzoa, and "Worms," Echinoderma, Spongida, Cœlentera, and others. In this state of "fry" most of the young of these various animals are more or less sensitive to even slight changes of temperature in the currents near the ocean surface. Indeed, it is said that a fall of temperature of only a few degrees in the water in which they spend this part of their lives will suffice to kill the fry of many species at once. Hence, if these animals are to reach the adult stage, and to leave any offspring, one of the first essentials to their wellbeing as a species is that they should not be liable to a chill in the earlier stages of their existence. One source of incongeniality may arise from surface currents drifting the fry from an area where the water is warm to another where it is not so; or, in another case, it may be brought about by one or other of the many oscillations of surface temperature which must have taken place in the past as much as they do at present.

If neither of these disturbing factors comes into operation, the whole of the species which thus spend the earlier stages of their existence at the surface may, other things being favourable, reach the adult stage, leave behind them progeny like themselves, or, in other words persist, with little or no important modifications, for periods of almost any length.

If, on the other hand, the area where these animals live is liable to be invaded by chill currents, then extermination of certain species that cannot stand the change necessarily follows, at least so far as that particular area is concerned.

Digitized by Google

Such variations of surface temperature may be, and probably are, in many cases, of a secular nature, and may be due to precessional or to other causes of a recurrent nature.*

After a period of extermination of some species by causes of this nature, the descendants of the original species, which had held their own in the areas adjacent where more equable conditions obtained, gradually extended their range, and took the place of their ancestors, probably becoming more or less modified as they did so, in the course of the lengthy period requisite to bring about the immigration.

It requires but little reflection to enable any one to perceive that the recurrence of such vicissitudes of surface temperature must carry with it consequences of the kind with which we are here concerned. Hence, we may conclude that where we are dealing with a set of strata in which the vertical range of the fossils is very small, and where allied species take the place in strata which we should expect to afford us examples of the older type, that we are dealing with rocks in which nature has recorded the history of recurrent changes of temperature in the ocean-surface waters then covering that part of the earth's crust. I should regard each Ammonite zone in the Jurassic Rocks in this light; and, with equal confidence, should regard that in the history of the Ordovician and Silurian zones of Graptolites. And so with other groups.

On the other hand, where we find the same species, or assemblage of species, recurring many times throughout a great thickness of strata, as they do in the Lower Carboniferous Rocks, I should consider that fact as good evidence of the prolonged equability of the ocean-surface temperatures of the area over which such uniformity has been shown to prevail.

In other words, in those cases in which the conditions affecting the welfare of certain species are alternately favourable and unfavourable, it would be reasonable to expect that the transmutation of species would go on at a faster rate than where the conditions remained uniform.

* It may be remarked here, that it is in connection with these secular recurrent changes of ocean-surface temperature, in relation to changes of life in the past, we shall have to look in the near future in considering many questions in Geology, and especially those connected with the Age of the Earth.

Digitized by Google

At the close of Lower Carboniferous times, as is well known, a marked change occurs; but it is by no means certain that it affects the marine invertebrata, which, so far as I have seen, remained nearly the same from the one part of the period to the other. But with the plants, which respond more readily to changes of climate, and with the fish, to which the same remark applies with almost equal force, the case is different. I think that there is good evidence of a true unconformity, in North Yorkshire at least, between the Lower division and the Upper. This certainly implies at least a temporary upheaval of the land, and possibly something more than that. It is quite conceivable that such an upheaval might well be accompanied by a temporary change from an equable climate to one of a somewhat more continental character. In this case, and if this were so, we need have no difficulty in accounting for the well-marked break in the more sensitive forms of life to which this remark is intended to apply.

I may remark, in passing, that the entire change in the Graptolite species of the Moffat area between the Glenkiln, Hartfell, and Birkhill faunas can be readily accounted for in like manner by a temporary upheaval of certain land-areas, by which conditions favourable for the development of the free-swimming fry of the Graptolites were excluded over that area. That is to say, while the bottom in the Moffat area remained fit for the adults the surface was unfit for their young.

The principle is one of far wider application than there is space to treat of here, and it may help to explain palæontological anomalies in many other cases than those to which it has now been specially applied. It has been more fully discussed in a paper lately read before the Royal Physical Society "On the Cœlentera in relation to Geological Zones." *

As regards the important question of the correlation of the various subdivisions of the Lower Carboniferous Rocks I need only refer to the annexed comparative table of strata (see Plate I.), which will probably be sufficient to afford the answers that I should give in most cases.

* *Proc. Roy. Phys. Soc. Edin.*

Digitized by Google

Concerning the relations of the Carboniferous Rocks to those above and below, I can only say that there is often a slight unconformity, and still more often a marked overlap, between the local base of the Carboniferous and the Upper Old Red. Between the Old Red and everything older there is evidence of more or less unconformity everywhere in the British Isles. In the English Lake District, for example, an aggregate thickness of *five miles* of the older rocks was removed before the Upper Old Red was laid down. At the top of the Carboniferous, in Britain at all events, occurs the second largest stratigraphical break in the whole British series. Nowhere is the true Lower New Red, Dyas, or "Permian," conformable to the Carboniferous Rocks, although, except in text-books, it is nearly, or quite, everywhere conformable to the Trias. But as there is no "Permian" in Scotland, and not even the lowest member of the Trias, we are not much concerned with this.

On the other hand, some of the so-called "Upper Old Red" of the Clyde basin is probably Trias.

[In the original Address considerable attention was devoted to the influence of the structure of the Lower Carboniferous Rocks upon scenery, but this need not be reproduced here.]

Digitized by Google

No. III.—Boulders and other Evidences of Ice-action in Lochaber. By Colin Livingston, *Corresponding Member*, Fort William. With a Map [Plate II.].

[Read 12th April, 1900.]

The chief evidence of ice-action in Lochaber, as elsewhere throughout Scotland, is, perhaps, the configuration of its glens and valleys, caused in large measure by the denuding action of the glaciers of which they were at one time the beds.

The district is intersected by two main valleys, the best known, Glen More, which extends from the Argyllshire coast in the west, with the Island of Mull on one side and the district of Lorne on the other, to the Moray Firth on the east, lies along an anticlinal axis, with its two extremities occupied by the sea. The middle is partly occupied by a chain of lakes, Loch Ness on the eastern slope and Loch Lochy on the western. Loch Oich is really on the watershed, though it is naturally connected with the eastern slope, and artificially by the Caledonian Canal, with the basin of the Lochy in the west. The summit-level of the canal is only 100 feet above that of the sea, and the watershed at the bottom of the valley is some 20 or 30 feet higher. Loch Ness and Loch Lochy are both very deep—about 90 fathoms, and they are evidently due, in part at least, to the action of the ice, which first largely scooped out their beds, and then excluded from the depressions the detrital matter which now blocks the lakes at their outlet, and gradually, as the ice melted, gave place to water. The general direction of this valley is from S.W. to N.E.

Between Fort William and Banavie, at a point occupied by what is locally known as the "Moin Mhor" or the "big moss," this valley is intersected by another one not quite so regular in its outline, though well enough defined, which lies almost due E. and W., but at the eastern end towards Badenoch trends considerably to the north. This eastern part contains Loch Laggan, formed evidently in the same way as Loch Ness and Loch Lochy, and the western holds Loch Eil, an arm of the sea, and the freshwater Loch Eilt. On the eastern side the bottom elevation rises to about 1000 feet, after which it drops towards the valley of the Spey. On the western side no part of the bottom of the valley

Digitized by Google

rises above 400 feet, and the greater part does not exceed 100 feet.

The sides of these valleys are formed of lofty mountains, many rising from 2000 to 3000 feet above sea-level. In Ben Nevis, which occupies the south-eastern angle formed by the intersection of the two main valleys, they reach their highest altitude —4406 feet—and several summits exceed 4000 feet.

This configuration of the land determined the direction of glacial movement, so far as it is now traceable, but above an elevation of 2000 feet there is little remaining evidence of it. That at one time the ice-cap surmounted our highest mountains is more than probable, but evidence in support of this theory must be sought for elsewhere than on the mountain-sides, and requires a wide field. Here and there throughout the Lochaber district are to be found blocks of porphyritic agglomerate which may have been conveyed from the summit of Ben Nevis. If this was the actual site from which they were brought, the ice-sheet must, of course, have been of very considerable thickness above the present mountain-summits before it could bear such blocks along with it; and other indications are not wanting that the upper part of the ice-cap moved in great measure independently of the configuration of the valleys.

The most striking evidences of the former existence of glaciers in the district are the well-known "Parallel Roads" of Lochaber, seen in Glen Gloy, Glen Roy, and Glen Spean. It is not intended to go here at any length into the consideration of questions connected with the "Roads"; but it may be mentioned briefly that for a distance of over twenty miles they are distinctly marked in the various glens. They are *parallel* in the sense that their lines as they pass along the hillsides continue practically at the same relative elevation to each other, and this fact clearly indicates that they owe their existence to water, and are lake-margins.

In his latest paper on the "Parallel Roads," Prof. Jamieson accounted for their formation in a manner that appears entirely to satisfy the requirements of the case. Briefly it amounts to this:—Owing to the excess of precipitation on the west coast as compared with that on the east, the sheet of ice which formed on the former was much thicker than that on the latter, beyond the

Digitized by Google

present watershed of Scotland. As a consequence, when the seasons meliorated, the surface of the ground was first laid bare in the east, and the denudation proceeded gradually westward. In the glens in question, which are west of the existing watershed, lakes formed behind the retreating ice-barrier, and the Parallel Roads are the margins of these lakes. The levels of the successive lines are found to correspond with the elevation of cols by which the water would be discharged into one part or other of the valley of the Spey as the retaining barrier gradually receded westward.

The evidence to be met with, below an elevation of 2000 feet, that at one time the Lochaber valleys were occupied each by its own glacier, is abundant. It consists, in addition to the usual detrital covering of the hillsides, of—(1) Detrital Lines in the form of Lateral and Terminal Moraines, (2) Rock Striation, and (3) Boulders.

(1) Detrital Lines.

The lines of detritus are specially noticeable in the valley of the Spean at its junction with the Lochy. This is as might be expected from the fact that the Spean valley is the widest of our glens and has its sides formed of the highest mountains. From Spean Bridge to Fort William there is the small lateral valley of Auchindaull, connected with the united Spean and Lochy, where the lines are particularly evident. Within three miles of Spean Bridge four of these lines cross the public road from Fort William. In places they run into each other, but the general direction is for the most part preserved, curving in towards the Spean valley, which was the main bed of the glacier. One may be traced from near the base of Aonach More, a part of the Ben Nevis range, across a somewhat elevated moor into the Auchindaull valley, where, just above the gate to the farmhouse, it forms a ridge with the top horizontal, and at one time about 100 yards long, and known as "Tom na Brataich"—"the banner mound." It rose from 50 to 60 feet above the general level, but much of it now has been carried away for railway ballast, for which, from its gravelly character, it is specially adapted. The ridge is cut across by two trenches, evidently made for defensive purposes when the banner waved from its summit,

Digitized by Google

as the name implies—possibly before the great battle of Inverlochy in 1341, in which Donald Balloch defeated the Royal forces under the command of the Earls of Caithness and Marr.

A short distance behind it on the moor is another detrital mound known as "Tor Sonnachan"—"the pallisaded mound." The top is enclosed by a turf wall, probably used for defence in connection with the same battle, as defensive positions of this kind do not appear to have been used in the ordinary clan fights.

The line of which "the banner mound" forms part proceeds down towards the bottom of the Auchindaull valley, ascends the opposite side, and descends again towards the River Spean. In its descent it occupies the bottom of a small lateral valley for some distance, and here greatly resembles a great turf dyke about 30 feet high with a base of as many yards. On the opposite, or north side, of the Spean it is not to be seen near the river, but at an elevation of something like 100 feet above the river-bed it again assumes its dyke-like form, and may be followed almost to the extremity of the 850 feet "Parallel Road" on the shoulder of the hill above Spean Bridge—Meall na Luath.

The public road, in a distance of not more than two miles from "the banner mound," is crossed by at least three other lines, well-marked and traceable for considerable distances across the moor on either side. As might be expected, their continuity is a good deal broken, but they still retain their identity. A mound of considerable size belonging to one of them has been cut into for the supply of road-material, for which it is well suited, as it consists of small, sub-angular chips of stone. The little stream which flows towards the Auchindaull valley has cut a passage through this mound. "The banner mound," differing from this one, consists of gravel and fine sand, which indicates that it was formed under somewhat different circumstances. Its position—lower down the valley—would seem to imply that it was of earlier formation. There are numerous other accumulations of fine sand along the banks of the Spean and its tributaries at the same, or a higher level. One of these, about the same level as "the banner mound," but separated from it by the other lines, and at a distance of about two miles, is "the Brackletter Plateau"—a detached mass of fine sand several acres in extent,

Digitized by Google

which must have been formed before the Spean had there shaped its present course.

Plateaux of similar composition exist at Blarour and various other places on the Spean and in Glen Roy. But all these rest upon the sides of the hills, from which their material may have been obtained, while Brackletter is now cut off by the river from the source of supply.

On the wide plain extending from the foot of Loch Treig towards the Spean, the lower part of the River Gulbin, and the foot of Loch Laggan, there is a succession of moraine-lines connected, evidently, with the glacier from Loch Treig. They consist for the most part of blocks of stone with very little earthy or gravelly matter, except for a short distance from where they begin at the loch. These lines are so striking a feature along the plain that they have evidently given it its name, "An Sliabh Lorgach," "the track-moor," or "the moor having tracks."*

The lines radiate from the mouth of the loch, spreading out as they reach the plain and, as they advance, curving in towards the production of the axis of the loch-valley. In their upper part the various lines are more compact than where they advance and rise higher above the general surface. Lower down on the plain the blocks of which they are composed become more scattered, but still retain their continuity. The line highest up the hillside, between near the loch and Craig Dubh, has a height of over 20 feet in the forward slope, while that towards the hill is less, from 2 or 3 to 10 feet. About two miles beyond Fersit this line is crossed by the road to Strath Ossian. Towards the loch it reaches its greatest height, and has in its composition a large quantity of small detrital matter. Below the road the height grows gradually less, and the smaller material disappears as the line advances, leaving only an irregular curved line of loose blocks of stone, which become more scattered as they proceed.

On the north side of the Spean, opposite the Loch Treig depression, on the moor between Roughburn and (another) Craig Dubh above the public road from Fort William to Kingussie, there is an immense accumulation of large granite boulders piled over each other, in some parts forming irregular lines, and in others scattered over the moor. The area so covered is about

* See Mr. Jolly's paper: *Trans.*, vol. viii., part 1, 1886, page 45.

Digitized by Google

two miles long and in part over a mile wide. This formed the terminal moraine of the Loch Treig glacier with relation to the depression now occupied by the loch; but as the glacier would of course follow the valley of the Spean downwards, it is lateral in regard to that valley. The lines on the Sliabh Lorgach are partly lateral and partly terminal.

Above the farmhouse of Innish there is a short piece of moraine evidently connected with a glacier from Laraig Leachdach, a pass connecting the Spean with the head of Loch Treig.

In Glen Loy, on the other side of the River Lochy and opposite the mouth of the Spean valley, there is another well-marked lateral moraine along the hillside on the left bank of the River Loy.

In addition to these lines there are various continuous accumulations rising above the general detrital covering of the mountain sides, and indicating, as it were, the collision of cross-currents in the slowly moving ice-streams, as on Beinn Chlianaig, on the left of the Spean facing Glen Roy.

On the plain between the mouth of Glen Nevis and the River Lochy, in the direction of Inverlochy Castles—the old and the new—there are a number of rounded mounds, some of them considerably elongated, which doubtless also owe their existence to the glacial period. When one of these is opened up it is found to be composed of sand—sometimes very fine and beautifully white—gravel, almost if not quite rounded, and sub-angular chips of stone. These are more or less sorted, forming layers which are not horizontal, but appear as if their materials had been successively dumped down from a higher elevation.

These mounds and hillocks form no continuous lines, but are scattered broadcast, so to say, over the plain, which is from 30 to less than 100 feet above sea-level. There seems to be only one way of accounting for their number, and for their peculiarities in form and structure—that they have been formed in the crevasses of the glacier, when its ice had wasted away and thinned out till the fissures reached the underlying ground-surface, while there was still a general ice-sheet of considerable thickness. The torrents that swept the hillsides washed the earthy materials on the surface of the decomposing ice into the pits thus formed, and these were deposited, sometimes in a

Digitized by Google

rounded form, where a stream had for a time descended into an ice-caldron, or at other times elongating and spreading out laterally as the chasm changed its form in the moving mass.

Mounds of similar character are to be met with almost everywhere throughout the Highlands, as for instance on the Moor of Rannoch, where some of them supplied excellent material for bedding the sleepers on the West Highland Railway. Generally speaking they are most numerous on cols that connect the river-basins of the various rivers or those of their tributaries.

(2) Rock Striation.

In all the Lochaber glens striated rocks are to be found, and in some cases the striæ form groovings or flutings of considerable depth. In others they consist of fine lines scarcely observable, but easily recognised when once the eye has become accustomed to detect them. The glacier that issued, as already mentioned, from Loch Treig, smoothed down the rocks over which it passed. On the right hand side of the river the rocks for the most part are merely smoothed and rounded. They decompose readily by the action of the weather, and the striæ which undoubtedly once existed on them are now obliterated. Here and there quartz-veins project, showing the depth to which the rock has weathered, and the quartz-surfaces are smoothed as if they had been operated on by the lapidary. On the left hand, however, some 400 or 500 feet above the loch, and towards the shoulder of Meall Cian Dearg, the ridge that forms the sky-line as seen from below is deeply grooved and striated. The groovings spread out fan-like from the loch towards the lower ground on the left.

In various places down the Spean valley striated rock is to be met with, especially about the hamlet of Achluachrach, and in others along the road towards Roy Bridge. Everywhere the rounding of the rocks indicates the passing over them of some abrading substance moving towards a lower level. The sides of the rocks facing the upper parts of the valleys are rounded and smoothed, while those facing the lower parts are angular and splintered, from which the moving ice in its downward progress has broken off and carried away fragments with it.

The rocks about the watershed of the Laraig Leachdach, on the

Digitized by Google

one side towards Loch Treig-head, and on the other towards the Spean, are much striated, as is the case with those in Coirre an Eoin at the head of the Cour, which joins the river near Spean Bridge. The rocks on the N.E. side at the base of the Ben Nevis precipices are beautifully striated in places, and in Glen Nevis striated rocks exist on the side of Sgor Challum. About Fort William the rocks contain too much feldspar to be favourable to the retention of such markings. Only in one place, on the shoulder of Achintore Hill, somewhat above the highest point of General Wade's Road, have traces of striæ been observed. The rocks beyond the head of Loch Eil, south of Druimsallie, are deeply grooved, showing movement towards the loch, and some of the rocks at the roadside towards Glen Finnan have well-marked striæ.

In no part is the striation finer than on the shores of Loch Leven near North Ballachulish. It may be traced to a considerable height up the hillside from a point on the road to Callart about a mile after it leaves the main road. The slaty character of the rock makes it specially suitable for retaining such markings.

(3) Boulders.

The Lochaber boulders are innumerable, if under that name are to be included the masses of angular stones found in various places at the lower levels. Glen Nevis has a large number which appear to belong to the mountain sides of the glen and not to have been far carried, but quartzite boulders are entirely absent. The hills seen as one looks up the glen from its mouth, and apparently shutting it in—Stob Bàn and Scor a Mhaim—consist of quartzite in very thick beds, which cross the River Nevis some 10 miles up the glen, and rise again into mountain summits in the Coirchoillie group overlooking the Spean. Neither in Glen Nevis nor in Glen Spean do quartzite boulders show in any number, and the few to be met with are merely small fragments.

As already mentioned, thousands of granite blocks lie piled one above the other near Roughburn, some 20 miles from Fort William along the road to Kingussie, and within about a mile of the road. They have doubtless been carried across by the Loch Treig glacier.

Digitized by Google

At no great distance from this accumulation a detached hill rises above Murlaggan—Craig Dubh, 2160 feet—on whose shoulders lie a number of boulders of various rocks, some at least not known now to exist in the neighbourhood. The hill itself is of mica-schist, and some of the boulders are also of the same material but different in structure from that *in situ* in the hill. One or two are granite; others are of a sandy structure but different from ordinary sandstone. Fragments struck off by a hammer crumble readily, and the powdery matter produced by the blow is less silicious than in the case of ordinary sandstone. Rock somewhat similar is found *in situ* above Corriebeg on the north side of Loch Eil. But it is difficult to suppose that masses of rock could be carried from there and deposited on Craig Dubh without having also left traces elsewhere along the line of movement, and none, so far as known, exist. The passage of the main stream of ice if not higher than our present mountain summits would be down Loch Linnhe, rather than across the main watershed of the country. Those blocks on Craig Dubh apparently therefore belong to rocks at a greater distance, and at a greater elevation than that of our present mountain-summits. They are deserving of some special investigation.

In reporting to the "Boulder Committee" of the Royal Society of Edinburgh some years ago, I called attention to another form of boulder to be met with in various places along our hillsides, whose original site has not yet been determined. The rock has a vitreous fracture, and is very hard and tough, which makes it unsuitable for building purposes, and in places where the granite boulders and schistose blocks have been entirely cleared away these boulders still remain untouched. It is not, so far as can be ascertained, known anywhere *in situ*. The late Prof. Heddle of St. Andrews, in one of his visits to Lochaber, was asked to report upon these boulders specially, and as the material did not correspond with any he was familiar with, he called it for identification, and till something further should be known about it, "Livingston Rock."

One large block of this kind lies above the road at Inveroy near Roy Bridge. Another, much larger, lies above the Ben Nevis Distillery, near a path at one time followed in ascending Ben Nevis. Another lies about a mile above Fort William near

Digitized by Google

General Wade's Road to the south. There are many others, large and small, but these are the most accessible. They may have been brought from the mass of mountains in the triangular space between the Spean and the Spey, east of Glen Roy, but this is only conjecture founded on the fact that these mountains are not so well-known geologically as those to the west and south-west.

From Glen Nevis, by the valley of the Riasgaig, towards Loch Linnhe, a stream of boulders was conveyed and deposited on the N.E. shoulder of Meall nan Cleireach, where they lie in hundreds. A small ice-stream from Glen More passed westward towards the same shoulder by the col to the west of Fort William; this was joined by a smaller stream across a col from Glen Nevis, and the boulders of this joint stream are left in lines which indicate its course.

Of the boulders at a higher elevation, those deserving special mention are "Clach na Feadaige"—"the plover stone"—on the top of Beinn Riabhach (*Re-ach*) above Blarmachfaoldach; "Clach-a-Sgrogaidh"—apparently "the tilted stone"—on the ridge of Scor Challum, between the same place and Glen Nevis; "Clach-an-Acrais"—"the hunger stone"—to the south of the main valley on Meall nan Cleireach; and "Clach-an-Turmain"—"the nodding stone"—on Meall-an-t-Slamain, on the other side of Loch Linnhe opposite Fort William.

"Clach na Feadaige" is on Blarmachfaoldach Hill, about 1550 feet, with no higher point in the immediate neighbourhood. It may have come from Meall-an-t-Suihe. "Clach-a-Sgrogaidh"—about 1700 feet—is of mica-schist, with veins of quartz, which rests on edge and is inclined to one side—hence probably the name. Near it, and towards the brow of the ridge on which it stands, there is another large block lying flat; and on the south shoulder of a higher ridge, a short distance to the S.E., some ten or twelve blocks lie close together on the grassy slope. The edges of their fractures are quite sharp, and their material—mica-schist—is similar to that of the adjoining rocks, looking down on the Nevis, but separated from them by the ridge on whose southern slope they lie. They and "the tilted stone" appear to have been borne on the left edge of the glacier descending Glen Nevis, and to have been dropped in their present position, as it flowed in towards the lower valley to the south.

Digitized by Google

About two miles from these, a continuation of the same ridge to the east, and near the point known as Stob Ban, it consists of loose angular fragments of rock which evidently formed part of a lateral moraine connected with the Glen Nevis glacier.

"Clach-an-Acrais" has got its name from the fact that when the crofters of Blarmachfaoldach see the sun over it at mid-day they are ready for dinner. The mica-schist of which it is composed is studded with small garnets. Near it and only a little lower down are two other blocks of the same rock, their position indicating that they were brought from the N.E.—the direction of Glen More—or from the east—that of Glen Nevis—directions which correspond with lines of boulders at lower levels. Rock of much the same kind is found *in situ* in upper Glen Nevis, but at an elevation of not over 600 feet. As the summit on which they lie is comparatively detached, they must, apparently, have been brought from an elevation higher than their present position, though were it lying between ridges of greater elevation they might have been raised from a lower level.

Opposite Fort William, on the other side of Loch Linnhe, and near the summit of Meall-an-t-Slamain, is "Clach-an-Turmain," "the nodding stone." It consists of vein-granite, is rounded, and about 9 feet in diameter. It rests at an elevation of about 1400 feet on a bare shoulder of quartz-schist rock, and its apparently insecure position, looking as if a slight shove would push it over, has evidently given it its name. Tradition connects it with the Fingalians, who are said to have used it as a putting-stone, and to have thrown it from hilltop to hilltop. The summit of the hill rises between it and Fort William, but it is visible from points farther down on the east side of Loch Linnhe. From its position it appears to have found its way from the direction of the head of Loch Eil and Glen Finnan, where similar vein-granite is to be seen *in situ*.

The only other boulders that need at present be mentioned in any detail are those near the head of Glen Gloy, some 20 miles from Fort William. At some stage of what may be called the Ben Nevis glacier, as originating in the valleys surrounding this highest summit, the ice-stream may have found its outlet towards the head of Glen Roy into the Spey valley, or on to the eastern slope of Glen More. That such was the case when the ice-sheet

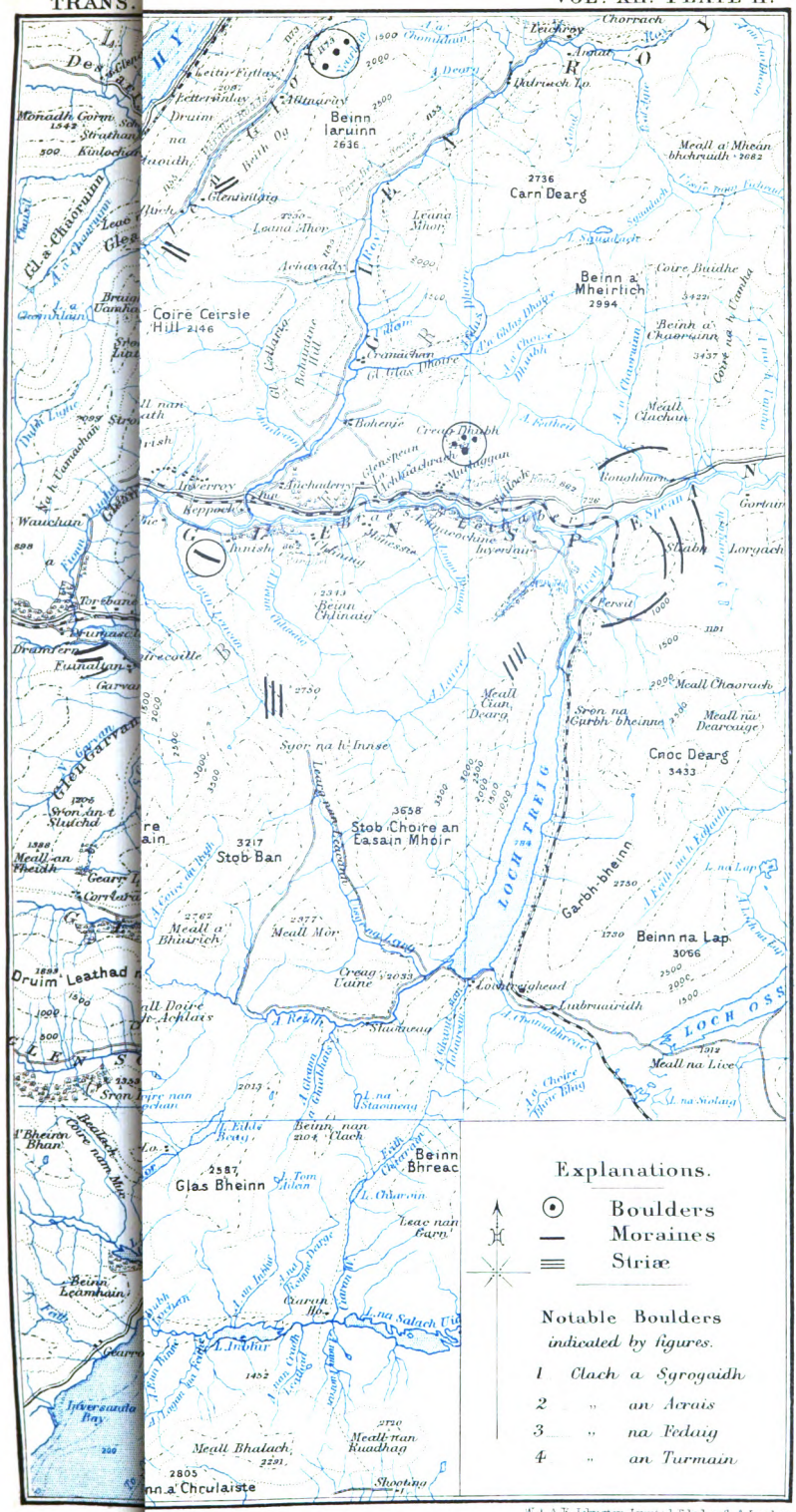
Digitized by Google

was as high or higher as the Ben, is not only probable but almost certain, though little evidence of such a movement can now be found. Generally speaking, the mountain-summits alone could supply such evidence, for as the ice-sheet lowered, its motion would be directed by the existing mountain-contours: and the still-remaining traces of ice-action almost invariably point towards the lower levels of our existing glens and valleys. The only exceptions of which I am aware are to be found in Glen Gloy. These were discovered by Mr. William Jolly, F.G.S., in one of his many explorations in Lochaber. On the shoulder between Glen Fintaig and this glen, at their junction, and below 1172 feet "Parallel Road," there are traces of glaciation, in the wearing of the rocks and their well-marked striation, which indicate a motion of the ice-stream upwards in the direction of the head of the glen.

Further on in the same direction towards the col, on a semi-detached shoulder of Beinn Iaruinn, and at an elevation of about 1500 feet, I found, a few years ago, a line of granite boulders, some of considerable size, though none very large, which ran nearly parallel with the axis of the glen. There are no higher summits in the immediate neighbourhood from which they could come, nor are they in line with any neighbouring points. The granite of which they are composed is similar to that in hundreds of boulders that lie on the top, and on the upper slopes of Meall-an-t-Suidhe (*tooie*), 2326 feet, a projecting shoulder of Ben Nevis. A glance at the map (Plate II.) will show that between the Meall (*lump*) and the head of Glen Gloy there is an unobstructed course, and that no point in the direct line rises over 600 feet. Sroin-nam-Bà, 1718 feet, which approaches nearest the line, would at most only slightly deflect the ice-current. There can be little doubt, therefore, that these boulders were carried from the Glen More front of Ben Nevis by an ice-stream flowing to the N.E., and the glaciation in Glen Gloy, already referred to, is additional evidence of such a stream having existed. The striæ are at the base of a rock which protected them from the ice-flow that, at a later period, passed down the glen, and has left its traces on the more exposed rocks.

In another part of the same glen, about half way between its mouth and Glen Fintaig, I have observed, at the foot of a precipice

Digitized by Google



W. & A. K. Johnston, Limited, Edinburgh & London

Mr Livingston's paper.

Digitized by Google

THE NEW YORK
PUBLIC LIBRARY

ASTOR, LENOX AND
TILDEN FOUNDATIONS

Digitized by Google

on the proper left of the river, striking evidence, in the form of striæ, of a boulder-fall, or detritus-fall, which must have occurred as the glacier which occupied the glen towards the close of the ice-period was gradually wasting away. In connection with this it has occurred to me when looking from a height to the westward at Loch Garth, and especially at Loch Farraline in Strath Errick on the south side of Loch Ness, that these lochs are at the base of an escarpment over which there must have been a great ice-fall, a fact which may account for the scooping out of the lake-beds.

The length to which this paper has already run forbids my giving particulars of boulders on the mountains to the east of Loch Treig, or of one in a remarkable position standing out of one of the "Parallel Roads" at Inverlair. But there is one other which must not be omitted. At "Blâr-a-Chaorruinn"—"the rowantree field"—in the valley of the Riasgaig, on a field once cultivated but now under grass, and near a small knoll used as a burying-ground, lies a block—of little note as a boulder, for its greatest measure does not exceed five feet—but unique in Lochaber as a cup-marked stone. In Eastern Inverness, in Nairn, and in part of Argyllshire, especially in the parish of Glassary, cup-markings are numerous on detached stones or on rocks *in situ*, but in all Western Inverness this is the only known instance of their occurrence.

Of the markings on this stone, which number about two dozen, some are small and indistinct, but most are of the ordinary size and depth—from 1½ to 2 inches in diameter and half an inch deep. It is a block of the local schist rock, and there is nothing in its position, nor are there any traditions connected with the place where it lies, which would serve, however remotely, to account for its special distinction. It is easily reached from General Wade's Road, being about a mile from the bridge across the Riasgaig, and some four miles from Fort William.

Fraoch-Bheinn, on the west side of Glen Finnan, at the head of Loch Shiel, has some remarkable boulders, and there are many more of which nothing can now be said. I shall, in conclusion, only mention a peculiar group of three or four which lie above the public road at the bend of Loch Eil, beyond Annat farmhouse. The rock of which they are composed appears to exist *in situ* in Glen Gloy, a short distance beyond Inverskilavuillin.

Digitized by Google

No. IV.—The Surface Geology of the Falls of Clyde District. By James Stark. With a Map [Plate III.].

[Read 12th October, 1899.]

The district immediately surrounding the Falls of Clyde consists of a rolling plateau, with a general elevation of from 700 to 800 feet above sea-level, rising with a gentle slope towards the southern uplands, and deeply trenched by the valleys of the Clyde, and those of such of its tributaries as come within the area described.

As far up as the town of Lanark the Clyde valley, though deep, is wide and open; the 600 feet contour-lines, which at Carluke are four miles apart, converge to less than a mile at Lanark, while the bottom of the valley lies from 300 feet to 400 feet below the general level of the plateau. At Braxfield, just abreast of Lanark, the bottom of the valley becomes greatly contracted, and assumes, for about half a mile, the form of a deep, narrow, and, in places, rocky defile. It then expands into a wide hollow about three-quarters of a mile across, at the foot of which the New Lanark Cotton-mills were built in 1784 by David Dale, for the sake of the water-power there available.

Passing onwards up the stream, we find that it enters this hollow through a second defile, enclosed by precipitous rocky walls over 100 feet in height. About 400 yards above the entrance to this gorge, and at a sharp bend in the river, occurs the Fall of Corra Linn, consisting of two broken leaps of some 30 feet and 60 feet respectively. Above this the river toils for half a mile along a series of rapids, bounded by rocky precipices, from 50 to 60 feet in height, until we come to Bonnington Fall, a perpendicular leap of about 35 feet. Above Bonnington comes another, but shorter, series of rapids, where the stream flows over broken edges of shelving sandstone, and beyond this, for a distance of nearly three miles, the rock is no more seen, the river pursuing its course quietly through an alluvial tract of ground between sloping banks and kames of sandy and gravelly drift.

Near the lower end of this quiet reach, the Clyde receives the waters of the Douglas from the south-west, at an elevation of about 580 feet above the sea; and from this point to the foot of

Digitized by Google

Corra Linn, a distance of a little over a mile, it descends about 180 feet. From there to the foot of Stonebyres Fall, three miles further on, it descends about 200 feet more, which gives a total fall of 380 feet in a distance of rather over four miles, while the general elevation of the plateau in which so deep a trench has been excavated maintains a fairly uniform level.

Opposite the mouth of, and extending far up the Douglas valley, the surface of the plateau is covered, for many square miles, with immense accumulations of gravel and sand; here heaped up into kames, ridges, and hillocks, and there spread out into gently rolling plains. The drift is of all degrees of fineness, from the coarsest shingle to the finest sand; and although all these varieties of material are often found apparently confusedly heaped together, still, in a general way, the further from the upland valleys the drift becomes the finer, until it merges into the huge drums of fine sand which may be seen at Carstairs and Carnwath.

Sections of the kames, cut through by the railway to Douglas and in other places, show that the materials of which they are composed are generally rudely stratified in lines more or less parallel with the sides of the ridges, and that thus they are original forms of deposit, and have not been eroded, like river terraces, out of pre-existing ones. A typical section may be studied in a gravel cutting amongst a clump of trees which stands on the left side of the road to New Lanark, at a point where the ground suddenly breaks away with a steep slope towards the river. Here a bed of finely stratified sand, streaked with partings of fine coal-debris, rests against the side of a ridge of coarse, cross-bedded shingle, composed of a collection of rounded and waterworn pebbles of the most heterogeneous description. Light-coloured sandstones, shales, and coals from the Douglas coal-field, porphyrites and chocolate-coloured sandstones from the Lower Old Red Sandstone, quartzite pebbles from the Downtonian conglomerate, felsites from Tinto, granites from Spango Water, jaspers, mudstones, greywackes, and cherts from the Silurian uplands, have evidently been brought down the valley of the Douglas Water, and spread over many square miles of country opposite its confluence with the Clyde, until, towards the east, they mingle with a similar accumulation (except

Digitized by Google

that it is without the Carboniferous pebbles) which has come down the Clyde valley, round the east flank of Tinto.

Comparing now the wide open valley below with the narrow gorges above the town of Lanark, no one can fail to realise the immense lapse of time needed for the erosion of the former, as compared with that required for the latter. The one is, in fact, a part of the old valley in which the Clyde flowed for ages prior to the glacial period, while the other is a new channel, dating subsequent to that epoch.

The onward march of a glacier tends to deepen and widen a valley lying in a direction parallel to its course, and through which it passes, and as this was the case with the greater part of the Clyde valley below Lanark, the glaciers have probably left it wider and deeper than they found it. The case was different, however, with that part of the old valley which lay across the track of the glacier from Douglasdale, and the first of the detritus brought down by that glacier must inevitably have filled it up to the brim. During the period of extreme cold, the glaciers became confluent, and the whole country was wrapped in a general ice-sheet, but as soon as the climate became ameliorated, and the glaciers began to melt away and retire up the valleys, the volume of water due to the melting ice seems to have spread out its burden of shingle and gravel over the general surface of the plain, heaping the materials into ridges, which were possibly moulded in hollows of the melting ice, and laying down sand in eddies, or in still water ponded back by temporary barriers of ice.

After the glacial period had finally passed away, the Clyde in this part of its course failed to find its now deeply buried ancient valley, so, taking the lowest levels among the surface inequalities of the drift, it speedily cut a way through it down to the solid rock, in which it is now wearing out a new channel, which the frosts and rains have not yet had time to widen out into an open valley.

The village of New Lanark is situated at a place where the present channel nearly coincides for a short distance with the ancient valley of the Clyde, which above this point has been filled up with over 300 feet of glacial drift, and now lies buried deeply under Lanark Moor. The deep hollow eroded out of the drift by

Digitized by Google

the Penclair Burn defines its direction, however, for over a mile. The confluence of the Douglas Water must then have been a couple of miles north of its present position, and the deep hollow below Corra Linn which now forms part of the valley of the Clyde was, probably, in pre-glacial times, a portion of the Douglas Water valley.

The River Clyde must have begun to excavate its new channel at the point where it first poured its waters into the ancient valley below Braxfield. After clearing out the detritus with which it was probably encumbered, a waterfall would be formed over the boundary of the ancient valley, which cutting its way backward has formed the gorge at Braxfield. At the same time another fall must have commenced at the point where the river, in its new channel, encountered the left bank of the pre-glacial valley of the Douglas, a short distance below the present position of Corra Linn. This fall has now worn its way back about three-quarters-of-a-mile to its present position at Bonnington. Its height, of course, would be limited by the level of the river-bed below it, but as soon as the first-mentioned fall had cut the Braxfield gorge back to its coincidence with the ancient valley at New Lanark, the detritus in the latter would speedily be cleared out, and a new fall formed where the Bonnington one began, but on a lower-level. This new fall is working in the line of the original Bonnington gorge, and has already cut its way back to its present position at Corra Linn. While this process has been going on the rains and frosts have been busy on the exposed sections of the drift filling the old river-valley, and have so denuded them as to form the wide hollow in which the mansions of Bonnington and Corehouse are situated, the deep corrie to the west of the road to New Lanark, and the steep-sided gully of the Penclair Burn.

The rock-formation in this part of Clydesdale is of Lower Old Red Sandstone age. At Corra Linn the strata are nearly horizontal, occupying, as they do, the centre of a long syncline. To the north-west the strata dip up stream, and to the south-east down stream, at gradually increasing angles up to very high ones, so that we have, at Corra Linn, the highest visible beds of a great series of reddish-brown, and generally fine-grained sandstones, with partings of shaley mudstones, which pass down conformably into the Upper Silurian anticline of Lesmahagow and Carmichael.

Digitized by Google

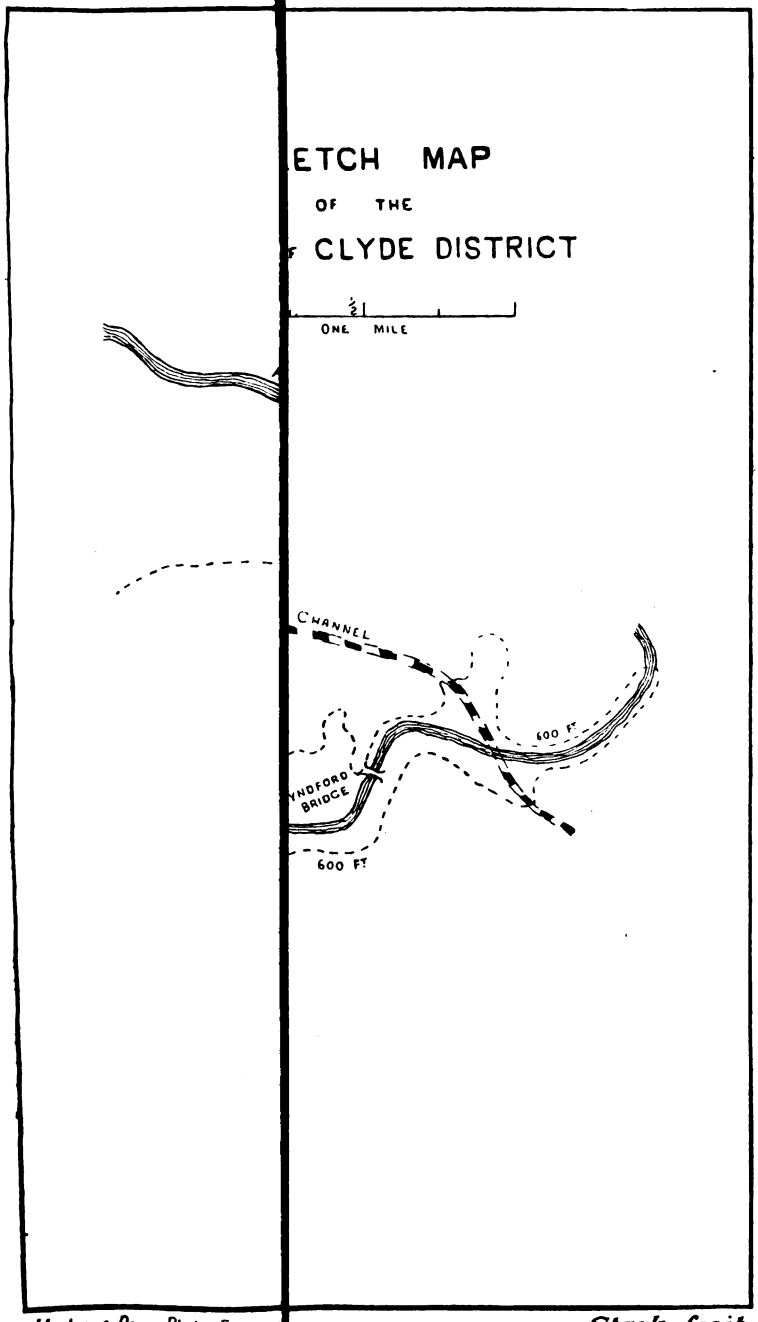
Networks of sun-cracks sometimes as much as 3 inches wide, and ripple-marked areas, such as may be seen at Bonnington Fall, indicate shallow-water and lacustrine conditions of sedimentation, but this is a matter apart from the subject of the present paper.

The present aspect of the Fall at Corra Linn is due to occasional thin partings of soft mudstone between massive beds of vertically-jointed sandstone. The mudstones, yielding more readily to the weathering action of the constant spray, leave the sandstones unsupported, and these in time fall away in masses, according to the jointing, which imparts a broken aspect to the Fall. At Bonnington, on the other hand, the present appearance is due to a dolerite dyke, which crosses the bed of the river at that point; and the indurated side of the cleft recently occupied by the dyke maintains, in the meantime, a vertical face, over which the river falls in a single leap.

The Mouse Water joins the Clyde about midway between Corra Linn Fall and Stonebyres Fall. Its course, from the north-east, lying across the path of the ice which filled the central valley of Scotland, was consequently choked up with glacial drift. On the melting of the ice-sheet the Mouse failed to find its ancient valley near its confluence with the Clyde, and has since cut out the gorge of Cartland Crags, doubtless by means of a fall, or series of falls, which, commencing at the rocky boundary of the Clyde valley, have long ago worn themselves out, leaving behind them a romantic ravine half a mile in length, and in places 400 feet in depth. At the same time the drift filling up the ancient valley has been so washed out as to plainly define its course through the grounds of Baronald immediately to the east of the Crags.

Assuming the substantial accuracy of Dr. Croll's calculations that 80,000 years have elapsed since the close of the last glacial period, and as it is a fact that Bonnington Fall is now about three-quarters of a mile further up stream than the point at which it must have started, we may conjecture that the average rate at which the Bonnington gorge has been cut out is about a foot in twenty years. Adding the length of the gorge at Braxfield to that cut by Corra Linn Fall, and allowing time for clearing out the Boulder-clay which once filled the old river-valley at New Lanark, the rate of cutting out the Braxfield gorge appears to have been about the same as that allowed for the Bonnington gorge. Both

Digitized by Google



Hislop & Day Photo-Engrave

Stark.-fecit.

Digitized by Google

THE NEW YORK
PUBLIC LIBRARY

ASTOR, LENOX AND
TILDEN FOUNDATIONS

Digitized by Google

the Cartland gorge and that at Stonebyres are considerably shorter than those just mentioned, but a long period has evidently elapsed since the cutting of the Cartland gorge was completed, and the upward advance of the Fall at Stonebyres must have been greatly retarded by a thick bed of intensely hard conglomerate, full of quartzite pebbles, which lies across the river course about 300 yards below the present position of the Fall. The deep caldron worn in the bed of the stream just below testifies to the lengthened period during which this conglomerate bed must have arrested the eroding action of the water.

Digitized by Google

No. V.—The Gold-field of North-Western Ontario, Canada. By R. W. Dron, Assoc.Inst.C.E.

[Read 8th February, 1900.]

It is only within recent years that the Province of Ontario has been recognised as a gold producer. The first official record of the output is for 1892, when gold to the value of about £7000 was recovered. In 1898 the value recovered had increased to £55,000 sterling, and there is little doubt that 1899 will show a considerable increase on this quantity.

Practically all the gold recovered has been from reef-mining, because in the gold-mining regions there are few streams in which gold-bearing gravel could accumulate. The absence of placer gold probably explains to a great extent why prospectors and gold-seekers have so long passed through this country, *en route* to the Western regions, without discovering its auriferous nature. Another circumstance which has doubtless retarded the discovery of gold-veins is the fact that their outcrops are in very many cases obscured by the thick brushwood, or covered by swamps and lakes.

The district visited by the writer in September, 1899, is that known as the Seine River and Lake of the Woods district, and is situated in the extreme western part of the Province of Ontario. It consists principally of a great plain with an elevation of between 1000 and 1500 feet. The contour of the country is very irregular, being much broken by low rounded hillocks rising to a height of 50 to 100 feet, and there are numerous lakes thickly studded with small islands.

The evidences of the great ice-sheet which once covered the country are everywhere abundant. The glacial striæ and grooves indicate a movement of the ice towards the south and south-west. The drainage of the district flows mostly to the north into Hudson Bay. The surface-soil is remarkably thin, and the writer saw no deposits corresponding to the Boulder-clays and "drumlins" of Scotland. There are large areas of swamps, or "muskegs," apparently the site of shallow lakes which have become filled up by decaying vegetation.

The pre-Cambrian rocks in which the gold-veins occur have

Digitized by Google

been divided by the Canadian geologists into two sections—the Huronian and the Laurentian formations.

On the geological maps some of the gold-bearing areas are indicated as belonging to the Laurentian formation, but the accuracy of the maps in this respect is open to a good deal of doubt. By many geologists it is considered that all the gold-quartz veins are found in the Huronian. Certainly any occurrence of gold in the Laurentian is quite exceptional, but several veins have been found near the contact between the two.

The Huronian rocks consist mostly of quartzite, with hornblende and felsite schists and greywackes. In these Huronian schists there are evidences of great igneous activity, both intrusive and contemporaneous, although the majority of the volcanic rocks have been altered into schists and schistose conglomerates.

In the Lake of the Woods district there are numerous granitic intrusions, and in many of these cases the occurrence of gold seems to be intimately associated with these intrusions. In the Regina mine, on the Lake of the Woods, the vein traverses both the intrusive granite and the Huronian diabase schist. At the Micado mine the fissure in which the quartz has been deposited has traversed both the granite and the altered trap. Many other instances of the same kind can be given, from which it is evident that the veins were formed at a later period than the granite. The presence of gold in the veins can hardly therefore have been caused by the granite. The intrusion of the granite may have been caused by the same agency as formed at a later period the fissures in which the gold was deposited.

There appear to be two distinct classes of veins found in Western Ontario. First, true fissure-veins with walls more or less clearly defined; in many cases the walls have acquired a schistosity parallel with the vein, thus giving it an appearance of being a stratified deposit. In several mines those fissure-veins have been proved to a sufficient depth to warrant a belief in their permanence, but the occurrence of gold seems to be somewhat erratic. The mines have not yet been opened up on a sufficiently extensive scale to enable a reliable opinion to be formed as to the nature and shape of the ore-shoots.

The second class of veins consist of lenticular masses of quartz interbedded with the schists. In many cases those quartz lenses

Digitized by Google

have been found rich at the surface, and have caused great expectations followed by great disappointment.

In some cases the lenses occur with sufficient frequency and regularity to repay the cost of exploration and development, but in the majority of cases they are only a temptation to inexperienced prospectors, and their failure has caused the district to receive an undeservedly bad name.

Several of the mines have been established on veins which are locally, but incorrectly, termed "dykes." These so-called "dykes" are sometimes as much as 200 feet wide, and represent fissured areas impregnated with quartz and sometimes mixed with an altered green chloritic material. At the Hammond reef mine a vein of this material is being quarried, and a large milling plant is in course of erection for the treatment of the ore. The vein is from 100 to 200 feet wide, and is expected to yield about 4 to 5 dwt. per ton.

The ore found at most of the mines is not of a very refractory nature. About half of the value generally occurs as free gold, and the balance can be satisfactorily extracted by cyanide or by the chlorination process. It is said that in some cases ore which was very rich at the surface has become refractory at a very short distance down, mainly owing to the presence of arsenical pyrites. I question if there are many *bona fide* cases of this kind. Refractory ore forms a good excuse to cover the incompetency or dishonesty of parties who are opening up mines with British capital.

From a general review of all the circumstances of the district, the writer believes that Western Ontario may become a large gold-producing province; but until the management of the mines falls into more competent and experienced hands there will be many mistakes made, and much money will be thrown away on unproductive work.

Digitized by Google

No. VI.—A Group of Short Papers. By John Smith. With Four Diagrams.

[Read 8th February, 1900.]

(1) On a Flexed Structure in the Pitchstone of Corriegills, Arran. With a Diagram (fig. 1).

(Summary.)

In this paper Mr. Smith described a block of Pitchstone which showed flexed structure in one of the bands of the rock. It lay on the shore a little way above tide-mark, and not far north of the exposure of the great pitchstone sill which traverses the sandstone at Corriegills. In one of the bands, which in this, as

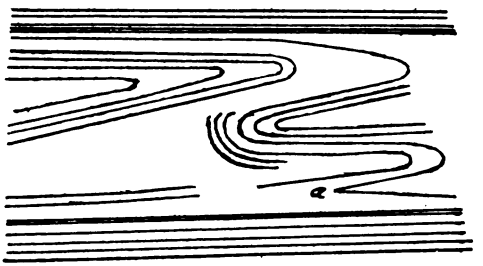


Fig. 1.—Flexed structure in Arran Pitchstone.

in pitchstone generally, are parallel to each other, there was a curious flexed structure about 5 inches wide, and, so far as seen, 9 inches long, though it was evidently much longer, the rest being obscured by the weathering of the surface. It had probably resulted from unequal cooling, the flexed part having reached a less viscid stage than the material in front and behind it. The sharp angle shown in the flexing (see *a*, fig. 1.) may perhaps indicate the direction in which the pitchstone was moving, *i.e.*, an opposite direction from that to which the angle points.

Digitized by Google

(2) On Drawn-out Spherulitic (?) Structure in a Trap Dyke near Balloch Pier, Great Cumbrae. With Two Diagrams (figs. 2 and 3).

(Summary.)

The author described in minute detail the appearances presented by a peculiar structure he had found in the trap rock of a dyke about 200 paces N.E. from the telegraph cable pole at Balloch

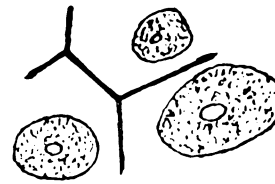


Fig. 2.—Cross section of parts of frames and three sub-cylinders.

Pier, in the island of Great Cumbrae. It showed cylinders and sub-cylinders set inside an angular framing of straight lines. The conclusion he reached after thorough examination was that these

Fig. 3.—A complete sub-cylinder.

curious markings in the trap had been at one time globes within globes, and when the viscid material was in motion horizontally they had been drawn out into the shapes now seen. (See figs. 2 and 3.)

(3) On Globular Structure in a Trap Rock near Neilston, Renfrewshire. With a Section (fig. 4).

This exposure of globular trap occurs near Shilford, on the line of the new Lanarkshire and Ayrshire Railway. The balls are about 6 feet in diameter, and occur near the bottom of a section 30 feet deep. None were seen touching each other, every one

Digitized by Google

being enclosed in recently-decomposed trap. The outer portion of each globe, for about a foot deep, was traversed by thin veins, the principal ones being concentric, and the smaller ones reticulating with the longer ones, and sometimes crossing them. Along the sides of several the trap was altered, and lighter-coloured than the rest, an alteration quite different from the recent weather alteration on the outside of the globes. The balls do

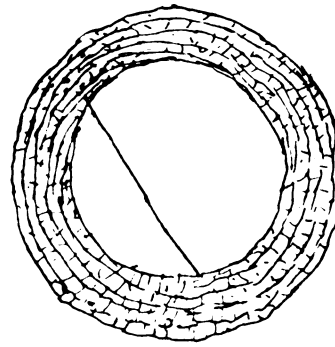


Fig. 4.—Diagrammatic section of a 6-feet Trap Ball, showing the principal and the reticulating veins.

not impinge on one another, so that their sides are not flattened, nor are they arranged over each other as in columnar trap. Inside them the rock is remarkably solid and veinless. In one a joint is seen passing through, but it does not cross the veins. This internal part—about 4 feet in diameter—is dark grey, and slightly porphyritic, the outside coating with veins being dirty-white. There has clearly been a shrinkage of the outer crust of each large globe, and a subsequent infilling of the cracks so produced, though before this took place these parts of the balls must otherwise have been as solid as the centres still are. (See fig. 4.)

(4) On Volcanic Ash with Beds of Sand and Gravel, near Neilston, Renfrewshire.

Half-a-mile S.W. of Neilston, in a cutting of the new Lanarkshire and Ayrshire Railway, 12 feet deep, in purple ash, there occurs a band of gravel containing pebbles up to 4 inches in diameter, and

Digitized by Google

some way below this are three bands of dirty-grey sand. All these bands are lenticular. Some time ago Mr. John Mackie, one of our members, described * alternating ash- and sand-beds which occurred at Crofthead Mills in the same neighbourhood, but those presently under notice are at a much higher level, and of entirely different quality. In neither case, however, was there any appearance of stratification. I have seen nothing of these beds in the Carboniferous system, the material resembling very closely in colour the refuse from chemical works known as "Blue Billy." They are so pure that unless comparatively recent it is difficult to account for their occurrence. No Boulder-clay has been detected under any of them, but if the coarse gravel bed which lies above them belongs to Drift period date, they may be preglacial, and perhaps of late Tertiary age. We have abundance of so-called Tertiary dykes, and why not Tertiary ash-beds?

(5) On a Freshwater Limestone underlying a Marine Limestone, near Paisley.

This limestone occurs in an old quarry at Jenny's Well, near the White Cart Water, between Blackhall and the Cart Bridge. The section is as follows:—

Limestone with Crinoids and Marine Shells, space grassed over (say),	24 inches.
Limestone with a few Freshwater Ostracoda,	8 ,,
Oil-shale crowded with Freshwater Ostracoda, and (in part) with Fish Remains,	14 ,,
Limestone with a few Freshwater Ostracoda,	7 ,,
Shale (soft) with Freshwater Ostracoda,	20 ,,
Limestone crowded with Freshwater Ostracoda,	4 ,,
Surface of Water in Quarry,	—

All these Ostracoda appear to belong mostly to the genus *Carbonia.*

In Craigenglen, Campsie, there are thin bands of freshwater limestone, as was pointed out by the late Dr. John Young in his Campsie Monograph.† If the Paisley horizon is a continuation of the Craigenglen one, it will therefore be some distance below the Campsie Main Limestone series. Whatever position it occupies,

* *Transactions*, vol. xi., part 2, 1900, page 299.

† See page 38 in "The Geology of the Campsie District." By John Young, LL.D., F.G.S. (*Trans.* vol. i., part 1), 3rd ed., 1893.

Digitized by Google

the under limestone beds in it are, so far as I know, the only freshwater limestones south of the Clyde in the Carboniferous Limestone series.

(6) On the Boulder-clay at Hamilton Hill, North of Glasgow.

With a few other members I visited, on 27th January, 1900, and for the first time, the exposure of Boulder-clay at Hamilton Hill, but unfortunately the section could not be approached on account of the great quantity of material which had slid down the face after the recent heavy rains. An examination of the heaps of boulders lying near, and which had been picked from the clay, showed that the bulk of them were local—say, from within a radius of 10 miles, and that a few more were from as far as Glen Falloch and Loch Garabal granitic area east of Loch-fyne-head. What struck me most was the appearance of the clay itself, as it was strongly, though not completely, of the greywacke type, or, in other words, that it had in great part been derived from metamorphic rocks.

There are here, then, three remarkable facts:—1st, the stones and boulders are principally local; 2nd, a small number of them are from a distance; and, 3rd, the clay, in bulk, has come from a distance, as well as a large number of small and minute stones. There are no sand-beds in the deposit, and from its uniform colour the conditions which prevailed during its deposition must have been very equable, and must therefore have formed only a single episode in the great glacial epoch. The surrounding district for miles is composed of Carboniferous strata, and therefore the Hamilton Hill Boulder-clay cannot be a so-called "ground-moraine" derived from local rocks. More probably it was laid down in sea-water, which was kept constantly charged with mud carried in by streams flowing from underneath Highland glaciers, and from the melting of floating ice.

Digitized by Google

No. VII.—The Carboniferous Limestones of Scotland, with their Coals. By R. W. Dron, Assoc. M. Inst. C.E.

[Read 10th January, 1901.]

The productive Coal-measures of Scotland are practically confined to a belt about thirty miles wide, stretching across the Central Lowlands from the Firth of Clyde in a north-easterly direction to the Firth of Forth. On the north-western boundary of this belt they are occasionally found lying more or less conformably on older strata, but are generally cut off by a series of upthrow faults, which run nearly parallel with the Lennox and Ochil Hills. These hills are largely made up of great sheets of andesite of Calciferous Sandstone age, interspersed, especially in the western district, with numerous volcanic necks of the same age—necks which now form prominent features of the landscape, such as Dumbarton Rock, Dumbuck, Dumgoyn, and Dungoil.

The south-western boundary is formed by a remarkable line of faulting which has thrown up the Silurian rocks of Kirkcudbrightshire, and those of the Leadhills and of the Moorfoot and Lammermuir ranges. At many points this fault exhibits a vertical displacement of at least 10,000 to 12,000 feet. Although the coal-fields within those boundaries are now cut up by denudation into a number of separate basins, there can be little doubt that in Carboniferous times they formed one continuous series, probably extending for some distance northward, and overlapping the Old Red Sandstone of the marginal Highlands.

The Carboniferous series as developed in this belt is sub-divided as follows :—

1. Coal-measures :—
   - Upper Red Sandstones.
   - Upper series of Coal-seams.
   - Lower series of Coal-seams.
2. Millstone Grit or "Moorstone" rock.
3. Carboniferous Limestones :—
   - Upper series of Limestones.
   - Coal-measures.
   - Lower series of Limestones.

Digitized by Google

4. Calciferous Sandstones :—
   Shales, Cement-stones, and Sandstones, including the Oil-shale series.
   Sandstones, Conglomerates, and Cornstones, merging into Upper Old Red Sandstone.

During the early Carboniferous period the Lowlands of Scotland, together with the greater part of Ireland and of England, formed an area of long continued depression. The English and Irish area was under clear water most of the time, and great beds of limestone were accumulated on the slowly subsiding bottom. This sea became shallower towards the north, and in the Scottish area various successive land-surfaces were formed, which from time to time sank beneath the sea and were covered over with deposits of sand and mud. The beds of limestone formed in Scotland at this time were comparatively thin, from 2 feet to 10 feet being the general limit, although in some exceptional cases a thickness of as much as 100 feet has been attained. Tracing the same beds southward into England and Ireland we find a gradual thinning out of the intervening sandstones and shales, together with a thickening of the limestone seams. In the north of England and in Ireland these seams have become solid beds thousands of feet thick, which are prominently exhibited in the Mountain Limestones of Northumberland. Under these conditions coal-seams were being formed in Scotland at the same time as the beds of limestone were being deposited in England and Ireland. Had the fates seen fit to make Ireland at this period an area of shallow water instead of one of deep water what a difference would it have made in the prosperity and development of that country! Scotland was then the scene of great volcanic activity, and great bodies of lava and of ashes flowed over the country, filling up the seas and estuaries, and forming the interbedded igneous rocks characteristic of the Lower Carboniferous formation.

A careful study of the geological conditions under which the Carboniferous Limestone Measures were deposited is of very great importance in connection with the future working of our coal-fields. According to my calculations more than one-fourth of the coal still remaining to work in Scotland is in the seams to be found in that portion of this series which is concealed under the Millstone Grit and the Coal-measures. In estimating the probabilities of finding workable coal in those concealed

Digitized by Google

areas a consideration of the geological history is necessary in order to arrive at any satisfactory opinion regarding the condition in which the coal-seams are likely to be found.

A general study of the Carboniferous Limestone coals as found in Scotland shows that the coal-field may be divided into three distinct districts, in each of which the deposition of the seams has been affected by different conditions. There is first a strip from 6 to 10 miles wide running across the country in a north-easterly direction, from about Girvan in Ayrshire to Elie in Fifeshire. On the south-east this district is bounded by the great series of faults throwing in the Southern Silurian uplands. On the north-west it is bounded by a line of faulting which can be traced first along the north-west of the Girvan valley and at the north-west of Patna. The fault disappears below the Coal-measures of Ayrshire, but re-appears again to the north-west of Muirkirk. It there forms the boundary of the Muirkirk and Douglas coal-fields. At Muirkirk the fault throws the Silurians against the Lower Limestones, and to the South of Lesmahagow it throws the Old Red Sandstones against the Upper Limestones. To the east of Lanark the line of faulting becomes obscured, but somewhere in the vicinity of Carnwath it appears to form a junction with another fault running in nearly the same direction from the southern boundary of the Douglas coal-field. The combined faults then continue along the base of the Pentland Hills and form the north-west boundary of the Edinburghshire coal-field. They are seen at Portobello on the shores of the Forth, and again on the Fifeshire coast, where, after passing through Kilconquhar, they form the northern boundary of the St. Monans and Pittenweem coal-basins.

In the district between those boundaries the coal-seams of the Carboniferous Limestone series have attained their greatest development.

The number of workable seams, and the total aggregate thickness at various points, are as follows:—

	Number of seams.	Thickness in feet.
Girvan,	6	31
Patna,	2	17
Mansfield (New Cumnock),	5	37
Muirkirk,	8	47

Digitized by Google

	Number of seams.	Thickness in feet.
Glenbuck,	7	35
Coalburn,	8	37
Ponfeigh (Douglas),	14	57
Edinburghshire,	34	95
Pittenweem,	9	40

This shows an average thickness throughout the district of 45 feet of coal.

The remainder of the Scottish area may be divided into two districts by a line running in a north-westerly direction from Carluke to about Kirkintilloch.

In the south-western district, embracing North Ayrshire, Renfrewshire, and portions of Lanarkshire and Dumbartonshire, the coal-seams are very poorly developed. Large areas, such as those at East Kilbride and at Auchenheath, contain only 2 feet or 3 feet of workable coal. In the Paisley and Hurlet area a maximum thickness of 16 feet is found; to the west of Glasgow, at Garscube, there is about 12 feet of coal. At Dalry the coal is only about 6 feet thick, and further south, by Stewarton and Loudoun, the coal-seams are either absent or very thin and unworkable. Even allowing for the thicker seams at Garscube and Hurlet, the average aggregate thickness throughout does not exceed 5 feet or 6 feet.

In the north-eastern district, including the eastern portion of Lanarkshire, with Stirlingshire and Fifeshire, the coal-seams are generally better developed than in the south-western district.

The number of seams, and the total aggregate thickness at various points in this district, are as follows:—

	Number of seams.	Thickness in feet.
Kirkintilloch,	5	10
Denny,	2	6
Bannockburn,	5	13
Bo'ness,	8	30
Fifeshire,	12	46

This shows an average thickness of only 21 feet, as compared with 45 feet in the first district. It is also to be noted that there is a progressive thickening of the coals going from west to east.

The coal areas outside of those three districts are of comparatively little importance.

Digitized by Google

Scattered throughout the Silurian area to the south-west of the great boundary fault there are numerous outliers of Carboniferous Limestone, together with some areas containing Coal-measures and Permian Sandstones. There is no doubt that the Carboniferous Limestone series once extended over the greater part of the south-west of Scotland, but the conditions under which it was there deposited were not favourable to the formation of coal-seams.

On the north-eastern margin of the coal-field the conditions are somewhat different from those prevailing on the south-west. Although, as already mentioned, the actual boundary is mostly formed by a series of faults, still the general succession of the beds can be traced downward as we proceed to the north-west from the coal-field.

The lower division of the Carboniferous Limestone series is found in contact with the shales, cement-stones and igneous rocks of the Upper Calciferous, and this series again is lying more or less conformably on the Lower Calciferous and Upper Old Red Sandstones. How far the coals of the Carboniferous series originally extended over the older measures it is impossible to say. It is just possible that they may have extended to the edge of the metamorphic schists of the Highlands. If this is a correct assumption, then the area which has been denuded of thousands of feet of coal-bearing strata is greater than the whole area of the coal-fields which are left. It is more than probable that the most of this area was beyond the limits of the Carboniferous sea, but however that may be, if the coals were once there they are gone now, and there is not very much to be gained by speculations on the subject.

A very important factor in causing the difference between the coal-beds of the western and eastern areas of the Carboniferous Limestone series was undoubtedly the great volcanic activity which had its main centre in the district between Dumbarton and Campsie during Calciferous Sandstone times.

The great sheets of lava which were poured forth at this time, and which now form such prominent features of the landscape in Renfrewshire and Dumbartonshire, must have had a profound influence in altering the conditions of the early Carboniferous sea or lake. The volcanic centre would also be subject to many local depressions and elevations even after the active eruptions had ceased. An evidence of this local irregularity is found in the

Digitized by Google

district of Possil, Kirkintilloch, and Cumbernauld, where it is almost impossible to establish an exact correlation between the various seams. Again, at Kilsyth we find four seams of ironstone, but in the Denny coal-field, three miles distant, there are only two seams of ironstone, and these cannot be correlated with any of the Kilsyth seams. Most of the Kilsyth coal-seams have disappeared altogether at Denny, but some of them come in again further east at Bannockburn. The beds of Kilsyth and Bannockburn appear to overlap and dovetail into one another in the neighbourhood of Denny.

A study of the Calciferous Sandstone series between Lesmahagow and Carnwath shows that there also the bottom on which both this series and the Carboniferous Limestone were deposited was subject to local movements. Ample evidence of this is found in the frequent overlaps. For instance, at Auchenheath the Calciferous Sandstones are either absent or almost entirely covered by the Carboniferous Limestones which overlap them, and are found resting directly on the Old Red Sandstone. To the east of Lanark the upper group of the Calciferous Sandstone overlaps the lower group and rests on the Old Red Sandstones. Many similar instances might also be given.

Going further east beyond the probable area of the volcanic disturbance much greater regularity is found. There is little difficulty in tracing the correspondence between the coal-seams of East Stirlingshire, Linlithgowshire, and Fifeshire, and, as already shown, the thickness of the coal is much greater.

The importance of these observations with relation to the study of the concealed areas of Carboniferous Limestone coal is obvious. We have seen how the coal-field may be divided into three separate districts. In the first, the total thickness of coal varies from 15 to 95 feet, with an average thickness of 45 feet. Wherever these coals pass below the newer formations in that district they may therefore be followed with some reasonable hope of finding workable seams of considerable thickness.

In the second district, that forming the western division of the coal-field, the geological conditions seem to point to considerable irregularity, and the coal-seams are generally few and thin. This indicates that there is much more uncertainty as to the conditions which may exist under the newer measures, and that although

Digitized by Google

attempts will undoubtedly be made to exploit the coal-seams, those attempts will be somewhat speculative. It is a question of great geological and economic interest as to how far the unfavourable conditions of the west have extended into the Carboniferous Limestone series lying below the Upper Coal-measures of the Lanarkshire basin.

The somewhat arbitrary division line running from Carluke to Kirkintilloch would pass through near Cambusnethan, Bellshill, and Coatbridge, approximately parallel with the course of the River Clyde. This would indicate that the whole of the Clydesdale basin is to be included in the non-productive area, but that the Carboniferous Limestone coals underlying the Airdrie, Slamannan, and Shotts district belong to the third or eastern division. Throughout the whole of this third district, including also Alloa and Fifeshire, the seams may not in the aggregate reach so great a thickness as in the first district, but they are almost sure to be found in a workable condition, and sufficiently regular to justify their exploitation. If the local circumstances are properly taken account of, sinkings to the lower seams may therefore be prosecuted with every hope of success. Before passing from this subject it is worthy of observation that the lower section of the coals of the Coal-measures, *i.e.*, the Drumgray coals and the underlying seams, are very poorly developed throughout the second district, both in Ayrshire and Lanarkshire; but they are found of considerable thickness in the first and third districts.

It is an interesting speculation as to why there should be so great a difference in the character of the coal-seams on the two sides of the line of faulting which form the north-west boundary of the first district. This fault, which, at Girvan on the one hand and Muirkirk on the other, is of sufficient size to throw the Silurians in direct contact with the Carboniferous Rocks, appears to pass through the central basin of Ayrshire without affecting the Upper Coal-measures. If this observation is correct it would apparently indicate that the fault was in existence during the deposition of the Carboniferous Limestone series, so that while a coal-seam may have been in course of formation on the south-east side of the fault on the north-west, the conditions were unfavourable for the formation of coal-seams. While this theory may not meet all the facts of the case it is difficult to see how else

Digitized by Google

the deposition of coal-seams could have been affected by the presence of a fault.

The Officers of the Geological Survey seem to have adopted the same line of reasoning regarding the fault which forms the division line between the coal-fields and the Southern Silurian uplands, as is shown by the following quotation (Explanation to sheet xv., p. 32):—

"We find that in ascending the Nith valley the Carboniferous Limestone series, which is so well developed in the Thornhill basin, thins out towards the north, until along the south-eastern borders of the Sanquhar coal-fields it disappears altogether, and the overlying Coal-measures come to rest directly on the Lower Silurian rocks. No Carboniferous Limestone beds re-appear until we reach the great fault, immediately on the north side of which they come in in force. It is difficult to understand how this should have happened, unless on the supposition that, at the time when the Carboniferous Limestone series was in the act of deposition, the line of fault was represented at the surface by a steep bank shelving to the north, which formed the limit of the limestone series on that side, but which, as the whole region continued to sink, was gradually buried under the continuous sheet of Coal-measures which stretched through the Sanquhar valley northward into Ayrshire."

Digitized by Google

No. VIII.—The Shore Section at Portincross, Ayrshire. By James Stark. With a Section.

[Read 10th January, 1901.]

There is probably not a more interesting section anywhere in the West of Scotland than that exposed along half a mile of the shore at Portincross, on the Ayrshire coast, opposite the Lesser Cumbrae. The coast line, from the place in question, to the neighbourhood of Ardrossan, is occupied by a series of soft red sandstones belonging to the Lower Calciferous series, dipping, at low angles, generally in a southerly direction. On the west shore of Ardneil Bay these rocks are seen to be suddenly truncated by a fault ranging towards the south (A in diagram on next page). West of this fault comes a series of red, mottled, and grey sandstones, and deep red mudstones, standing on edge and striking parallel with the fault. Crossing it in a westerly direction is a dolerite dyke, 25 feet in thickness, which, at the fault, is inclined towards the north, at an angle of 10 degrees from the perpendicular, which increases to 25 degrees as it disappears below low-water mark. This is the same dyke which runs through the village of West Kilbride, two miles distant, where it has a thickness of 60 feet, and is vertical.

Passing on over the edges of the vertical sandstones for a distance of 200 yards, we come to another fault (B) which ranges parallel to A, and beyond it appears a series of neutral-tinted strata, also standing on edge, and so severely crushed and contorted that most of the beds assume quite a lenticular aspect. Near low-water mark, the succession is somewhat as follows:—

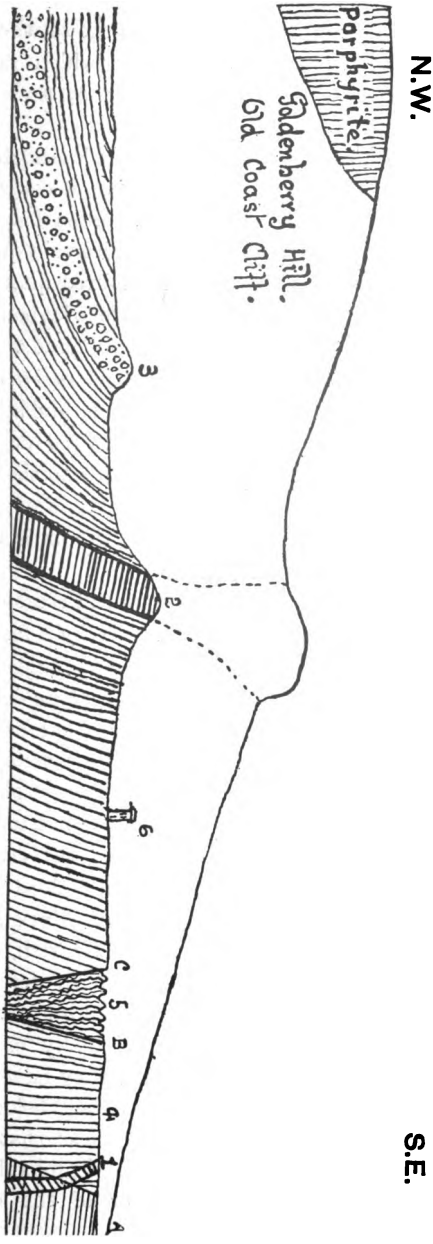
1.	Highly indurated Purple Sandstone, which might almost be termed a quartzite, - -	50 feet.
2.	Arenaceous Shale, - - - - - -	2 ,, 6 inches.
3.	Sandstone, similar to No. 1, - - - - -	6 ,,
4.	Grey Calcareous Shale, - - - - - -	30 ,,
5.	Sandstone, similar to 1 and 2, - - - - -	16 ,,
6.	Grey Calcareous Shale, - - - - - -	20 ,,
7.	Purple Sandstone, - - - - - - -	20 ,,

These beds make up a thickness of about 155 feet. They are very considerably metamorphosed, and the shales, especially, change rapidly, both in texture and in colour, along the lines of outcrop.

Digitized by Google

EXPLANATION.

A, B, C.—Faults.
1. Continuation of West Kilbride Dyke on Shore, Ardniel Bay, crossing fault A.
2. Dolerite Sill at Portincross.
3. Quartzite Conglomerate, 300 feet thick.
4. Red Sandstone Division of Calciferous Sandstones.
5. Supposed Ballagan Beds.
6. Portincross Castle.



Shore Section at Portincross, Ayrshire, from South-east to North-west.

Digitized by Google

They are also so jammed and crushed together, that the strike varies greatly, though its general trend is towards the south-west. These beds are abruptly cut off by a fault (C), which ranges S.S.W., so that it converges rapidly with fault A, and they evidently meet at no great distance from the shore.

Beyond this fault (C) we find another series of red sandstones, harder and darker than those between the faults, occasionally showing sun-cracked areas, and containing numerous bands of rough breccia, composed largely of fragments of white vein quartz, with a proportion of rounded pebbles of liver-coloured quartzite. These beds dip away from the fault at an angle of about 45 degrees, which continues fairly uniform for 200 yards, then steadily increases for 250 yards further to a great intrusive sheet or sill of dolerite, under which the beds appear to dip, and against the further side of which they lean at an angle of 80 degrees. From this point the dip rapidly lessens for 200 yards to the well-known Portincross conglomerate, which dips N.E. at an angle of 25 to 30 degrees, and 200 yards further on the strata are horizontal.

The old coast-line is here marked by a lofty mural escarpment of red sandstone, capped for a considerable distance by a mass of hard red porphyrite, which fills a wide and deep hollow, suggesting the section of an ancient valley. The porphyrite, at its deepest part, occupies about half the height of the cliff, and presents, in the "Three Sisters," a succession of boldly projecting precipices, 300 feet in height. The vertical jointing of the porphyrite contrasts sharply with the horizontal bedding of the sandstones.

Various opinions have been expressed regarding the crushed and altered beds, occurring between the second and third faults (B and C). They have been regarded as an inlier of Silurian age, but it is difficult to see how so small a section, if Silurian, could have been so greatly displaced. They have also been described as an upthrow of volcanic mud. There can be no doubt, however, that though now greatly altered, they were originally of sedimentary origin, and I would suggest the view that they have been faulted, not upwards, but downwards, and that they belong to the Upper division of the Calciferous Sandstone series; that they are the equivalents, in fact, of the Ballagan beds, and probably the same rocks as appear at the south-west corner of the Great

Digitized by Google

Cumbrae, where they are also faulted down against the red sandstones, though not crushed nor turned so completely on edge as they are at Portincross. The fact that the West Kilbride dyke, vertical elsewhere, assumes an inclination towards the north on crossing the fault (A)—the displacement increasing till the dyke disappears under water—seems to indicate that some movement has taken place even since the dyke was injected, probably in Miocene times, and that the movement of the faulted beds has been downwards. It will be noticed that the direction of the faulting, and the strike of the vertical strata, are roughly parallel with the great marginal Highland fault, which crosses diagonally the islands of Bute and Arran, and it is probable that these disturbances are connected with earth-movements having some relation to that great dislocation.

Coming now to the beds to the north of the third fault (C), it will be seen that these are darker and harder than the vertical sandstones, which, with the numerous pebbles of liver-coloured quartzite occurring amongst them, gives them the aspect of belonging to rocks of a greater age. The conglomerate north of the dolerite sill, nearly 100 feet thick, and crammed with quartzite pebbles, has a striking resemblance to the basal conglomerate of the Old Red Sandstone, as seen leaning against the Highland schists at Callander and Aberfoyle. As already remarked, the great marginal fault crosses from Bute to Arran, at no great distance from Portincross, and it seems a fair inference that the materials for the conglomerate here were derived, during Upper Old Red or Lower Calciferous Sandstone times, from the denudation of the Lower Old Red conglomerate which originally bordered the great fault.

The large size of the majority of the pebbles, many of which are more than a foot in diameter, seems to indicate that they have not been transported from a great distance, and the fact that they diminish in size towards the east, together with the presence along with them of many pebbles of Highland schist, also indicate that the source of supply lay in the direction of the marginal fault.

The disturbed and faulted condition of the sandstones of the district renders it a difficult matter to determine their real thickness and correlation. The vertical beds, at all events, have a thickness of 600 feet; from the third fault (C) to the dolerite

Digitized by Google

sill it can hardly be less than 900 feet; and from the sill to the top of the horizontal sandstones exposed in the cliffs forming the old coast-line at Goldenberry Hill about 1000 feet more. These rocks all belong to the Upper Old Red Sandstone, or to the Lower Calciferous Sandstones, and have been derived from the denudation of the once elevated ground along the Highland fault, which is now mostly beneath the waters of the Firth, or lies deeply buried under its own ruins.

Digitized by Google

No. IX.—Notes on a Recent Excavation in Sauchiehall Street. By John Wallace.

[Read 14th February, 1901.]

During the course of some excavations which were lately made in Sauchiehall Street at the corner of Thistle Street, and which revealed the presence of layers of Boulder-clay interspersed with other beds, I thought it would be of interest to bring their occurrence before the Society, and took some notes for that purpose. The ground at the locality indicated stands at about 100 feet above sea-level.

On the top there was a bed of Boulder-clay of an average thickness of 12 feet. Below it there lay a bed of loose stratified sand about 4 feet thick, and at the junction between it and the overlying clay its dip was about 20 degrees to the south-west.

Below the sand-bed, at the south-west point, there occurred a bed of laminated muddy clay, 6 feet 4 inches deep, which decreased very rapidly to a point about 45 feet north-east from the south-west point. Below it there was another bed of Boulder-clay, which averaged about 9 feet in thickness, and which lay on the Carboniferous Sandstone rock.

In the whole length of the cutting four bores were put down to a nearly uniform depth of 45 feet, and I here give the journal of each.

Bore No. 1 was sunk at the south-west point to a depth of 45 feet 6 inches, and showed the following in descending succession :—

Boulder-clay, - - - - - -	10 feet 4 inches.
Loose Stratified Sand, - - - -	3 ,,
Laminated Muddy Clay, - - - -	6 ,, 4 ,,
Boulder-clay, - - - - - -	4 ,, 7 ,,
Sandstone, - - - - - -	7 ,, 6 ,,
Shale, - - - - - - -	2 ,, 10 ,,
Sandstone, - - - - - -	2 ,,
Shale, - - - - - - -	7 ,, 11 ,,
Sandstone, - - - - - -	1 ,,

Digitized by Google

Bore No. 2, sunk 90 feet from the corner one (No. 1).

Boulder-clay, - - - - - -	11 feet 4 inches.
Loose Stratified Sand, - - -	4 ,, 9 ,,
(Laminated Muddy Clay not present.)	
Boulder-clay, - - - - - -	5 feet 3 inches.
Sandstone, - - - - - -	2 ,, 6 ,,

Bore No. 3, sunk 50 feet north from Nos. 1 and 2, and north-east of No. 4.

Boulder-clay, - - - - - -	13 feet 2 inches.
Sand-bed, - - - - - -	4 ,, 2 ,,
(Laminated Muddy Clay wanting.)	
Boulder-clay, - - - - - -	11 feet 3 inches.
Sandstone, - - - - - -	1 ,, 6 ,,

Bore No. 4, sunk north-west of No. 3.

Boulder-clay, - - - - - -	11 feet 4 inches.
Sand-bed, - - - - - -	4 ,, 6 ,,
Laminated Muddy Clay, - - -	3 ,,
Boulder-clay, - - - - - -	6 ,,
Sandstone, - - - - - -	2 ,, 7 ,,

Digitized by Google

No. X.—The Geology of the Elvanfoot to Wanlockhead Railway (with Special Reference to the Drift). By John Smith.

[Read 30th May, 1901.]

Drift-cuttings.—The sections exposed in the cuttings of the new railway from Elvanfoot to Wanlockhead, especially those in the Drift formation, are of great interest to the student of geology, all the more so as they show clearly that *the drift here has been deposited in water*, which fact lends a strong support to the theory that there was a deep submergence of the land during the drift or glacial period.

The railway rises above sea-level from 889 feet at Elvanfoot to about 1520 feet near Wanlockhead, and thus gives an unprecedented range of sections at high levels in which to study the drift-beds.

For the first mile or so it runs on top of the old delta beds* of the Elvan Water, which here appear to have been partly denuded away by that stream, and, possibly, also by the Clyde, before they had cut their channels to the present depths. The railway makes no deep cuttings here, but occasionally exposes a few feet of alluvium, or re-arranged gravel.

Just before coming to the Elvan Water there is a section in the upper part of the drift, the top portion of which consists of gravel with interstratified layers of sand and abundance of boulders up to three feet in diameter, some showing striations. This gravel rests on laminated muddy sand, and boulders begin to appear at the bottom. Some layers in the muddy sand are crumpled, as if they had been deformed by ice grating at the bottom of the water in which the bed was being deposited. From this point a fine view of the delta-drift of the Elvan is obtained, looking down the stream, which has cut away a large part of the deposits from its north side, while the opposite side shows a continuous bank of delta-drift from 30 to 40 feet in thickness above its surface, but the rock is not reached.

Between the railway bridge and the mouth of the Leadburn

*Chambers, in his "Ancient Sea Margins," 1848, mentions nearly a dozen "sea margins" in this district, ranging from 830 to 1362 feet above sea-level. Pp. 216-219.

Digitized by Google

an area of the thickest drift on the Elvan Water occurs, having evidently been influenced by the Leadburn, and this part may be called the Delta of the Leadburn. A river-section of it shows 50 feet of drift. Some of the beds are lower in position than those in the railway cutting, and exhibit stratified beds of drift with laminated clay, but the stream has not reached the rock. Boulders occur in this drift, and the largest one in the district—a greywacke, 15 feet by 12 feet—projects from the side of the bank, about 10 feet above the stream. A good view of the delta, which is more than 1000 feet above sea-level, is to be had from the Leadhills road.

Above the mouth of the Leadburn the drift on the Elvan is comparatively thin, and forms a striking contrast to the thick drift of the Leadburn Delta. Further up than this the Elvan gets the name of the Shortcleugh, and the highest drift on it is that of what may be called the Windgate Delta, at over 1300 feet above sea-level. On the Leadburn itself the drift reaches 60 feet in thickness at 1300 feet above sea-level, and shows stratification.

As soon as the railway crosses the Elvan it cuts into drift with traces of stratification and a considerable percentage of clay. In the drift here, as well as at lower levels, the stones and boulders are much more rounded than higher up country; in fact, the contrast is quite remarkable, and calls for an explanation. It appears to me that when the drift, from 1000 feet above sea-level downwards, was being laid down, glaciers occupied the valleys of the Elvan, Leadburn, and Shortcleugh, and floating off into the sea they deposited this drift, the rounding and scratching of the stones having taken place underneath the moving glacier-ice. When the land sank to under 1000 feet above sea-level the climate evidently became milder, and the glaciers seem to have disappeared, though perhaps a small remnant was left in the Windgate, a deep glen of the Lowther Hills. The evidence to be gathered from the drift-beds lying from 1000 feet to 1520 feet above sea-level will, I think, bear out this explanation.

From where the railway crosses the road at about 1000 feet above sea-level, till it again crosses at about 1300 feet, it climbs along the side of the hills. A number of drift-sections are cut through, and all the principal ones are clearly stratified,

Digitized by Google

and often contain boulders, some from considerable distances. On top of the drift, and at places even on top of the rock, there is a deposit of hill-wash, but it is easily distinguished from the drift.

Whenever the road at Leadhills Hass is crossed a deep cutting is seen in the drift, the top being about 1340 feet above sea-level. The stratification of the drift here is perfect, with a slight dip towards the south. Its upper 6 feet contain a large number of stones, mostly sub-angular and reaching a length of 3 feet. The lower 14 feet are largely composed of small stones, mostly sub-angular, and in the whole cutting there is very little clay, some parts being composed of very loose layers of stones without either clay or sand. The rock was not reached in this cutting. A nearly globular boulder of Loch Doon granite, about 3 feet in diameter, occurring at about 3 feet from the top of the deposit, was quite rotted to the very centre. If this boulder was transported in anything like a straight line, it must have come over ground at least 180 feet higher than where it lay—the col at Wanlockhead, and over the New Cumnock Hills, more than 2200 feet high. There are a number of Loch Doon granite blocks in the district.

The next notable section of drift on the new railway is that at Peter Stake Head, the top of which is about 1520 feet above sea-level, on the watershed between Glengonar and Wanlock Glen. Its stratification is perfect, and it contains no clay, like the drift on watersheds generally. On the west side the Wanlock Dod rises to 1808 feet, and on the opposite side the Stake Moss rises to 1780 feet; but the stratification of the drift, where the railway cuts through it, has not been influenced by the hill-slopes, the dip being at right angles to them, but has been arranged by currents coming from the south-west. If the land stood more than 1500 feet lower than at present, this part would have formed a portion of the Atlantic coast with islands on all sides, which would explain why the drift has been arranged by currents coming from the south-west. Few rounded stones are to be seen, those present being mostly sub-angular; the boulders reach 3 feet, and evidently have been carried by floating ice. Probably a large quantity of the materials of the drift here, which is coarser than at any other part of the railway cuttings, was carried in the same way. For want of a packing of sand, or

Digitized by Google

even of fine gravel in places, much of it is lying quite loose and open, and long thin stones are often seen broken across in position. The greatest depth cut in the drift of Peter Stake Head is 18 feet, but the bottom has not been reached. The coarsest drift in this long section is at the narrowest part of the col (or water-shed), where the currents would be strongest, but at the N.E. end, where the space is wider, the gravel is much finer, and in places the stratification is almost horizontal. On top of it there is a deposit of hill-wash, 18 inches thick, and unconformable to the underlying drift. This hill-wash is to be seen in a number of cuttings, and is quite different from the drift, as it always contains a large percentage of clay. Contrary to what might have been expected, it is the most difficult portion of all the material to excavate, as it is bound together by, apparently, hydrated oxide of iron. In two parts of this cutting the rock is reached; one appears as a boss or drum which at one time has probably been ice-worn. Before the drift had been laid down on it, its surface has evidently been much broken up by weathering, and this lends support to the theory already propounded that there was no land-ice in this district (with perhaps the exception of some trifling glaciers) after the land had sunk to about 1000 feet. There are some surface rock-drums here and at the head of Menock Glen, and all are much shattered by weathering. The top of the Peter Stake Head section is covered by 5 feet of peat.

The next two principal cuttings—between Peter Stake Head and the road near the Wanlockhead Hass—contain the usual stratified drift of the district, and in addition to the stones, mostly greywackes, there are also occasional bits of sandstone, one being 16 inches in size. As there are no sandstone beds in the district above 1000 feet of altitude these bits had apparently been brought up-hill, and probably from the Sanquhar direction, as they had a close resemblance to the Carboniferous Sandstones—dark yellow and purple—of that district. As Darwin has shown, there is nothing to hinder stones and boulders from being carried up-hill by shore-ice in a sinking area of land.

The drift in the last cutting of the railway before the Sanquhar road is reached contained a greater percentage of clay than any other in the Wanlockhead district, but it is at the

Digitized by Google

comparatively sheltered head of the Wanlock Glen, where currents would not be strong.

Glaciated Surfaces.—There is not a single glaciated surface of rock to be seen in any cutting on this railway, though much has been laid bare. That the rock-surfaces were glaciated at some period before the drift was laid down is highly probable, as has already been discussed; but since the drift was decidedly deposited in water, and evidently, I think, in sea-water, there is no vestige of evidence that the district traversed by the railway has been covered by land-ice: no part of the drift in any of the cuttings at 1000 feet or more above sea-level is the least contorted, and there are no moraine mounds. (It may be remarked that much of the ground at the "dry scaurs" looks hummocky, but this is artificial, as it has been turned over in the search for gold.) In fact all the drift of the district is very regularly spread out in the valley-bottoms and some way up the hill-slopes, and being all well-stratified it is difficult to see how it could possibly be a product of land-ice.

Owing to its loose, stony nature all the drift above the 1000 feet level has been very much decomposed since it was deposited, and is now of a dirty yellow colour, the bulk of the original material having been of a dark grey. Few scratched stones are to be seen in the railway cuttings above that height, though I have seen several in the district up to 1500 feet.

Rock-cuttings.—A good many rock-cuttings have been made, but there is no great variety in them. Massive greywacke occurs at Peter Stake Head, Leadhills Hass, and at several points between it and where the railway crosses the Elvan. It is much splinter-jointed and rotted; in fact in no cutting has really solid rock been reached unless in the old Hass quarry, where the railway cuts sideways into the hill, and at Peter Stake Head. Opposite Leadhills bedded rocks have been cut through, and the strata are on edge and exceedingly decayed.

Considering the great richness of the district in galena-veins it is strange that none have been met with in any of the railway cuttings. A few very thin quartz-veins have, however, been cut through during the course of the work, and it was the opinion of the miners that if these veins were followed up into the solid rock they would eventually become lead-bearing. Gold is widely spread,

Digitized by Google

and its dust thinly sown, over the district, but there is no reliable instance of its having been found enclosed in quartz. Speaking to a miner about the occurrence of gold he remarked to me, in grandiloquent language, that "the quartz of this region is too proud to carry gold," but for all that gold has often been got in vein-quartz.* There is a tradition in the district that Sir Bevis Bulmer, Master of the Mint to Queen Elizabeth, who had the workings here, crushed quartz for gold.†

Dykes.—The large Tertiary dyke which runs through Howk Wood Hill and Leadburn Rig has been cut into to obtain stone, and the cutting here shows that a number of boulders from it have been carried for a few yards up the glen.

Several elvanite dykes occur in the cuttings; opposite Leadhills; near Leadhills Hass; and between the latter and Wrispanly Viaduct. They are all of a light colour and of several varieties, as follows:—1, felspar and quartz; 2, felspar, quartz and mica; 3, felspar, quartz and pyrites; 4, occasional large crystals of felspar, sometimes over an inch in length. No. 2 is not to be distinguished in hand-specimens from some kinds of granite. In No. 3 the pyrites is cubical and striated. In No. 4 the felspar crystals often contain inclusions of quartz and pyrite.

The quartz in the elvanite dykes often occurs as roundish "blebs," and where the rock is solid these break across with the stone, but where it is slightly decomposed they project on the surfaces when the rock is broken, and have a strong resemblance to amygdules, though I have no proof that they are so. These elvanite dykes, in part the felstones of the Geological Survey, cut through the mineral veins of the district, showing that they are posterior in age to them. They run up to 20 feet in width and are a source of great trouble to the miner, being exceedingly hard and difficult to bore. They form the most durable material in the district for "road-metal," and bits may be seen projecting from the surfaces of the roads about Wanlockhead and Leadhills. Where these dykes reach the surface, weathering has broken them

* See *Trans.*, vol. vi., part 1, page 68.

† Prof. Harkness says [gold] "is found disseminated in small foliaceous particles or in round grains in the quartz-veins [of Wanlockhead and Leadhills] which traverse the greywacke sandstone and shale in a direction generally at right angles to their strike; and also in the detritus of the same rock."—*Quart. Jour. Geol. Soc.*, vol. viii., page 396.

Digitized by Google

up, often into thin plates. What the miners call "blue dykes," evidently diorites or dolerites, also cross-cut the mineral veins.

No other kind of dykes were observed in the cuttings, but in the drift there were several varieties of dolerite and diorite which probably came from dykes or sills traversing the local rocks.

A number of boulders of "haggis-rock" were dug out of the drift at below 1100 feet above sea-level, but I did not observe any of this rock *in situ* in the cuttings.

Very little radiolarian chert was seen in any of the drift, though the great bed of that material traverses the district about 1¼ miles N.W. of the line of the railway.

Hill-benches.—The hill-benches lend a strong support to the theory of a submergence of the land, as they are, I believe, notches cut in the hillsides by the waves of the sea. A few in the immediate neighbourhood of the railway may be given:—on Hunt Law, above 1500 feet; Stake Moss, W. side, about 1670 feet; Lowther Hill, N. side, at about 1800 feet; do., S. side, at about 1960 feet; and S.-W. side, at about 2200 feet. The 1960 feet one is 53 yards wide, of considerable length, and is backed by a steep bank; as they mostly all are. As previously stated it would take a submergence of over 2200 feet to allow Loch Doon granite blocks to have been floated in anything like a straight line over the New Cumnock Hills to where they now lie. On the Stake Moss, at about 1700 feet, there is a grey granite boulder.

Boulders Crossing.—A study of the district on a larger scale than has been attempted in this paper would show that the erratic blocks have often crossed their respective lines of carriage, a fact strongly in favour of their having been transported by ice floating in sea-water.

Conclusion (as to the Drift).—The thickest drift-section in the district is one, not cut through by the railway, on the Elvan Water, between the railway bridge and the mouth of the Leadburn. I have called the area in which it occurs "the Delta of the Leadburn," as it is evident that stream has had something to do with the great augmentation of its thickness at this point. There is an exposure of about 50 feet of it, all of which is stratified and contains boulders.

Below the 1000 feet level the stones and boulders in the drift are pretty much rounded and often show striæ. Above 1000

Digitized by Google

feet and up to 1520 feet in the railway cuttings the drift is stratified, even to the very watershed where the stratification is perfect, and often contains large boulders, some of them derived from sources as far off as the hills at the south end of Loch Doon. The great bulk of this drift is sub-angular, but there are occasional well-rounded stones.

I can see no way in which all this stratification, as well as the carriage and deposition of the erratics, can have been brought about, except by sea-water where floating-ice abounded.

The hill-benches (which I have explained to be remnants of old sea-shores) are, I think, strongly in favour of a deep submergence of the land to over 2200 feet. There was probably not much glacier-ice in this district after the land had sunk lower than 1000 feet below the present sea-level, but there is strong evidence of the existence of floating-ice, even after the land had subsided to 1700 feet. As the stratification of the drift-beds above the 1000 feet level in the district traversed by the railway was not contorted, there is no evidence of glacier-ice having occupied it after the drift-beds were laid down.

If the so-called "ground-moraine" is a product of land-ice—as many geologists think—and if the boulders in this district had been brought by land-ice, it is strange that there should be no "ground-moraine," and that the boulders should be lying either in or on stratified beds.

There is perhaps no place in the British Isles where the drift formation can be studied to so much advantage as in the Clyde Drainage Area—taking that term in its widest sense—as in it there is to be found material from about 200 feet below sea-level, shown by the bores at Millichin and Drumry,* to the heights treated of in this paper; and considering the slow rate at which earth-movements take place, with the occasional long pauses, indicated in this instance by the delta-beds and hill-benches, we must allocate to the formation of the drift an amount of time perhaps equal in duration to that which was taken up in the deposition of, say, a principal division of one of the older formations.

* *Trans.*, vol. iii., pp. 139 to 141.

Digitized by Google

No. XI.—Notes upon the Development of "Ausweichung" or Strain-slip in Schistose Rocks. By Peter Macnair, *Assist. Hon. Secretary.*

[Read 14th February, 1901.]

(Summary.)

In the course of his paper, Mr. Macnair pointed out that this structure was usually developed along lines parallel to the axes of the more acute folds in the schists. Many of these folds had been dragged forward or pushed over as if by some differential movement, which had resulted in the production of strain-slips running in a parallel direction to the lines of thrust. As a rule, they were developed to a greater degree of perfection in the finer argillaceous beds than in the more arenaceous rocks. In a phyllite, for example, they were often to be seen to an extent of eight or more to the inch, cutting through an earlier foliation, and bending the mica-flakes into a series of sigmoidal curves. In cases where further stretching had to take place actual rupture seems to have been the result, and the plates of mica have been re-arranged along the lines of strain. It was also pointed out that in such highly contorted belts as that running down the centre of Cowal in Argyllshire, the strain-slips had been actually folded themselves and crossed by later ones.

Digitized by Google

No. XII.—The Drainage of the Nile Valley. By Matthew Blair, *V.-P.*

[Read 9th May, 1901.]

(Summary.)

The author began by remarking on the variety of interesting points which the study of Egypt presented to the enquirer. Its unique position at the junction of three continents, its singular shape—a long green strip in a rainless land, and its entire dependence on its river, the Nile, which became smaller and smaller the nearer it got to the sea. Where its influence extended there was life, where it did not extend everything was barren.

He spoke of the teeming population, and of the high civilization, which had existed in this river valley from time immemorial, though no one appeared to have known whence came the life-giving, mysterious Nile. It seemed, like the one in the poet's "Vision of Mirza," to issue from an impenetrable cloud. It is now a familiar fact that the great equatorial Lake Victoria Nyanza is the main source of the river, but the fertilizing part of its annual burden of mud comes from the wearing down of the volcanic rocks of Abyssinia.

Describing the course of the White Nile from the Murchison Falls to Khartoum, Mr. Blair explained the great accumulations of "the sudd" which had blocked the river and so produced the great swamps above Fashoda. He spoke of the methods adopted for clearing the channel, and stated that this gathering of vegetable matter without soil might throw some light upon the formation of our coal-beds, the climate of Carboniferous times having probably been not very different from that of the Soudan at the present day.

Starting with the great river after its junction with the Blue Nile the author explained the position and construction of the great dams or barrages now being built at Assouan and Assuit for the purpose of regulating the flow of water, and for the assistance of navigation. He afterwards discussed the method of the excavation

Digitized by Google

of the Nile Valley; the existing evidences of a former rainy season in the districts now practically rainless; the system of irrigation at present in operation and its possible extension; and the difficulties attending the drainage of the great delta with the consequent effects upon the health of crowded centres of population like Cairo.

Digitized by Google

PROCEEDINGS FOR SESSION 1899-1900.

(42ND SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET, 12TH OCTOBER, 1899.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

Mr. JAMES WHITE read a paper upon "The Geology of North Berwick," in which he took North Berwick Law, the well-known eminence in that district, with its glaciated surfaces, as a text upon which to speak of his special theories on the origin of Boulder-clay, that intractable deposit which has afforded so much food for speculation and argument for many years. In the course of his remarks he contended for a succession of ice-ages, and for the land-ice origin of Boulder-clay, in opposition to the very generally held theory that it is a marine deposit—although he admitted that in places it might contain sea-shells and other organic remains.

Several of the members present, including Mr. John Smith and Mr. James Neilson (Milnbank), expressed vigorous dissent from the author's views, and strongly advocated the marine origin of Boulder-clay, while the Chairman (Mr. Blair) favoured the theory of its deposition by land-ice.

Mr. JAMES STARK read a paper, entitled "The Surface Geology of the Falls of Clyde District," which was illustrated by a map of the district and by diagrams. [See page 52.]

An interesting discussion followed, being taken part in by Messrs. John Smith, James Neilson (Milnbank), J. B. Murdoch, and others.

Mr. JAMES B. MURDOCH, Hon. Secretary, read a short paper "On the Proceedings of the Recent Meeting of the British Association at Dover" (at which he represented the Society as its delegate), giving a general account of the papers read in Section C (Geology), and of the various geological excursions. The meeting, though not one of the largest gatherings of the Association, was regarded as a very successful and interesting one.

SOCIETY'S ROOMS, 207 BATH STREET, 9TH NOVEMBER, 1899.

THE ANNUAL GENERAL BUSINESS MEETING.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

The HONORARY SECRETARY (Mr. Murdoch) read as follows:—

REPORT OF THE COUNCIL FOR 1898-1899.

At the beginning of a new year of the Society's work it has been the custom for the Council to present a short review of the proceedings during

Digitized by Google

the one just brought to a close, and the present notice is in continuance of the same salutary observance.

The Membership has remained nearly at its recent level, though a slight falling off is perceptible. This is to be regretted, for a growing membership would be to every member's interest. The Council would therefore again urge that each one should do what he could to add at least one name to the roll.

The Meetings of the session were 11 in number—9 ordinary and 2 special meetings—and most of them were well, and some of them largely attended, by members and their friends. At all these meetings sufficient material was brought forward to occupy the whole available time; indeed, occasionally papers had to be rather curtailed and discussion shortened to permit the business on the billet to be overtaken. It may here be pointed out that the Secretary's work would be lessened if members would give notice early in the session of their intention to bring up papers or show specimens, and so prevent him from being sometimes embarrassed for want of space for papers, and at other times for want of available material on the eve of a meeting.

The Papers which were submitted at the meetings were of considerable interest and value, and were largely on local subjects. Those contributed on the extra evenings by those two good friends of the Society—Dr. Traquair and Mr. John Horne—were delivered in the Large Hall at 207 Bath Street, and were much appreciated by large and interested audiences.

The Exhibition of Specimens formed a part of the business of most of the meetings, and as they were usually accompanied by notes, they formed an interesting and instructive feature of the Society's work, and one to which most of the members might make an occasional contribution.

The Lantern.—At almost every meeting the oxyhydrogen lantern was used with good effect, and it is now found to be an almost indispensable adjunct to the lecture-table for illustrative purposes.

The Excursions for the season were 12 in all (see Notes on Excursions, page 115), and no less than 5 of these were whole-day outings. They were all made to localities of interest accessible from Glasgow, and were on the whole extremely well attended, although a few suffered from adverse weather.

Evening Excursions. — There were also two evening excursions, for the benefit of such members as could not avail themselves of Saturday afternoons. It is thought that in future years similar excursions might be usefully arranged on a more extended scale.

Reports on a number of the excursions were submitted to subsequent meetings by their respective conductors, and several later ones have still to be given in.

The Library work will be reported on by your Hon. Librarian, Mr. J. S. M'Lennan, so it may suffice here to say that a number of high-class works were added during the year, and that a considerable use of the books has been made by members and associates.

Digitized by Google

Transactions.—The last published part (vol. xi., part 1) was issued to members in January of this year, and several papers of the later sessions are in type for a new part, to be ready, it is hoped, during this session.

Loss of Members.—Through the effect of business engagements we have to regret the withdrawal from our midst of an active working member—Mr. Robert Dunlop, a present Vice-President of the Society. Our good wishes go with him to his new sphere of labour—New Zealand—and it is to be hoped that no long time will pass over before he is able to pay us a visit, and tell us something of the geological phenomena of his new home.

There will be no manner of doubt as to the sympathy of the members being extended to that good old friend of the Society—Dr. John Young—in his withdrawal, it is to be hoped no long one, last session owing to his severe and long-continued illness, from which, it is gratifying to learn, he has to a great extent recovered. It is certainly the wish of every member that Dr. Young may soon be able to take his old place amongst us, and to give us the benefit of his wide knowledge.

The Honorary Librarian (Mr. M'Lennan) read his annual

REPORT ON THE LIBRARY.

Your Librarian has to report that the increasing interest taken in the Library by the members in former years still continued during the currency of the one now under notice.

The number of readers during the year was 43, and the volumes taken out were 233.

Of new books some 16 were added, and a like number of pamphlets were presented to the Society. The following sheets of the Geological Survey of Scotland on the 1-inch scale were procured for the use of members:—14, 22, 23, 30, 31, 32, and 40.

The publications of 20 British, 15 Colonial, and 17 American Societies have been received, giving a total of 52 Societies which exchange their Transactions with us.

The issues of many Foreign Scientific Societies—20 in all—which also come to us in exchange, have been transferred to the Mitchell Library.

The Honorary Treasurer (Mr. Wight) read his annual Financial Statement. (For an Abstract see page 123.)

These reports were unanimously approved, and a vote of thanks was awarded to the Honorary Secretaries, Treasurer, and Librarian for the work they had done on behalf of the Society during the past year.

Prof. C. Lapworth, LL.D., F.R.S., F.G.S., Professor of Geology and Physiography in University College, Birmingham, was elected President of the Society, Mr Matthew Blair, Vice-President, and Messrs. William Armour, Joseph Sommerville, and George R. Thompson, Members of Council, all for a term of three years.

Mr. Charles R. Cowie was elected a Member of Council to fill the vacancy caused by the election of Mr. Blair to the Presidentship.

Digitized by Google

Mr. J. B. Murdoch was elected Honorary Secretary; Mr. G. M. Pratt, Assist. Honorary Secretary; Mr. John Wight, C.A., Honorary Treasurer; and Mr. J. S. M'Lennan, Honorary Librarian—all for the term of three years.

Mr. J. R. M'Farlane and Mr. David Pearson were appointed Auditors for the present year.

Mr. William Lyle, 7 Beechwood Terrace, Shettleston, and Mr. William Purvis, 66 St. Vincent Crescent, were elected Ordinary Members.

Mr. JOHN SMITH exhibited a series of rocks and fossils from Derbyshire, collected by himself on a recent visit to that county with the Geologists' Association of London.

Mr. PETER MACNAIR, Assist. Hon. Secretary, exhibited under the Society's microscope several sections of an Ancient Volcanic Glass, from the Old Red Sandstone at Newport, Fife, which showed a beautiful perlitic structure. This glass was originally discovered by Mr. James Durham, F.G.S., Dundee.

Mr. JOHN RENWICK exhibited a fine specimen of a Fossil Fish from the Orange Free State, recently identified by Dr. Traquair as *Semionotus capensis*.

Mr. RENWICK also read an interesting paper on "The Rocks in the Islands of Loch Fyne." He stated that the geological structure of the rocks in the Loch Fyne area was very complex. They have not yet been found to contain any organic remains, so that their age cannot be definitely fixed, and they may be Lower Silurian, Cambrian, or even pre-Cambrian. Most of them are evidently of sedimentary origin, though they have undergone enormous changes since their deposition, whereby their original structure has been largely altered, and they now present a highly crystalline appearance. Even the igneous rocks of the area, which are mostly intrusive, have been metamorphosed, except a few probably of late Carboniferous or of Tertiary age. These great alterations in structure have been caused by repeated earth-movements on a large scale, resulting in great foldings, twistings and crumplings, the original lines of bedding having been, in many cases, quite obliterated, and new lines of foliation or cleavage superinduced. The difficulties in apportioning their true horizons are thus immensely increased.

The paper was illustrated by specimens of rocks obtained from the various islands in the area mentioned.

SOCIETY'S ROOMS, 207 BATH STREET, 14TH DECEMBER, 1899.

Mr. JOHN RENWICK, *Vice-President*, in the Chair.

Mr. JAMES S. M'LENNAN, Hon. Librarian, moved that a sum not exceeding £10 of the Society's funds should be devoted to Library purposes during the current session. Mr. W. Armour, C.E., seconded the motion, and it was unanimously agreed to.

Mr. James Paterson Cree, Westfield, Rutherglen, was elected an

Digitized by Google

Ordinary Member; and Mrs. Maclachlan, 5 Grosvenor Place, Hillhead; Mr. G. M. Cathcart, 2 Colebrooke Street, Hillhead; Mr. David Francey, 154 West George Street; and Mr. Thomas Law, Carfin Public School, Motherwell, Associate Members.

Mr. JOSEPH SOMMERVILLE read "An Account of the Rocks exposed on the shore between Innellan and Dunoon which were visited at the Society's excursion in August last." (See Notes of Excursions, page 117.)

Mr. MATTHEW BLAIR, *V.-P.*, read a paper, entitled "The Circuit of Arran, with special reference to the Ancient Sea-Levels." After giving an epitome of the general geology of the island as deduced from its exposed rocks, sedimentary and volcanic, Mr. Blair devoted his remarks to its "surface geology," as shown in the various Raised-beaches at levels of 25 feet, 70 feet and 120 feet above the present sea-level, and more especially in the great accumulations of water-assorted materials found in many parts of the lower areas. These latter, he contended, were almost invariably river-deltas, formed by the action of streams, and deposited below tide-mark at their debouchures into the sea when it stood at a relatively higher level to the land than it does at present.

In illustration of the paper a large number of views, from photographs taken by Mr. S. Fingland, were thrown on the screen by the oxyhydrogen lantern.

At its close a discussion followed, being taken part in by Mr. James Neilson (Milnbank), Mr. William Jolly, F.G.S., and other members.

SOCIETY'S ROOMS, 207 BATH STREET, 11TH JANUARY, 1900.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

Mr. G. C. DICKSON exhibited a specimen of a curious marine deposit from Table Bay, Cape Colony, South Africa, resulting from the wreck of the Indiaman "Haarlem" in 1728. He stated that the cargo of the vessel contained a large quantity of peppercorns and china ware, and the specimen exhibited showed broken china embedded in a matrix well interspersed with peppercorns. After north-westerly gales pieces of the deposit are still occasionally washed up. The bits of blue and white china ware are in a perfect state of preservation as regards the pattern and diaper, one piece showing a man's head and others leaves. A small vase was in a state of perfect preservation, and not even broken. The exhibitor recently extracted a whole peppercorn from the matrix, and when peeled it disclosed a perfect sphere of a light grey colour, and somewhat soft, which yielded a distinct taste of pepper to the tongue. The matrix is yellow-brown in colour, and an analysis showed that it contained about 61 per cent. silica, 25 per cent. oxide of iron, and 1 per cent. lime. The iron oxide is therefore the principal binding material. The present specimen contains a considerable amount of rusted iron, a sharp-cornered flat piece being especially noticeable, so that the large percentage of oxide in the analysis is easily accounted for.

Digitized by Google

Mr. DICKSON also exhibited two specimens of the remarkable tubes, found in sand-beds in Griqualand West, S.A., known as *Fulgurites*.

Mr. JAMES WHITE read a paper, entitled "A Short Critique on Mr. John Smith's paper, 'The Drift or Glacial Deposits of Ayrshire,'" recently printed in the *Transactions*, and expressed his strong disbelief in the stratification of the Boulder-clays, and their marine origin, and bringing forward many facts which in his estimation proved conclusively that they were the product of land-ice.

Mr. JOHN SMITH, in reply, said that the author had really not brought forward anything that could be called evidence against the hundreds of examples of the occurrence of stratification and the presence of marine remains in the Boulder-clays which were detailed in his Ayrshire paper, and that though the world had been gone over for instances in support of his theories, Mr. White had carefully and entirely avoided meeting these Ayrshire facts.

Remarks on the subject were also made by Mr. James Anderson, Mr. Wm. Jolly, F.G.S., and the Chairman.

Mr. PETER MACNAIR read a paper "On the Problem of the Marginal Highlands" (second portion). [For an Abstract see *Trans.*, vol. xi., page 273.]

The paper was illustrated by diagrams and specimens. At its close a discussion was taken part in by Mr. John Renwick, Mr. James White, and Mr. James Stark.

SOCIETY'S ROOMS, 207 BATH STREET, 8TH FEBRUARY, 1900.

Bailie WILLIAM MACLAY, *Vice-President*, in the Chair.

Mr. JOHN SMITH exhibited a "Peat Pebble" from a Raised-beach near Irvine.

Mr. R. W. DRON, C.E. and M.E., exhibited a number of maps issued by the Geological Survey of the United States of America, and contrasted the way in which such things were attended to by the authorities there compared with the parsimony of our home Government. These maps, quite equal to anything issued by the British Geological Survey, whose maps on the 1-inch scale were sold at six shillings each, were published at the price of one shilling each, a sum which placed them within the reach of any one.

Mr. JOHN SMITH read "A Group of Short Papers," which contained the following (see page 61):—

(1) On a Flexed Structure in the Pitchstone of Corriegills, Arran.
(2) On a Drawn-out Spherulitic (?) Structure in a Trap Dyke near Balloch Pier, Great Cumbrae.
(3) On Globular Structure in a Trap Rock near Neilston, Renfrewshire.
(4) On Volcanic Ash with Beds of Sand and Gravel near Neilston, Renfrewshire.
(5) On a Freshwater Limestone underlying a Marine Limestone, near Paisley.

Digitized by Google

(6) On the Boulder-clay at Hamilton Hill, north of Glasgow.

Several of Mr. Smith's papers were illustrated by diagrams and sections.

Mr. R. W. DRON, C.E. and M.E., read a paper on "The Gold-field of N.-W. Ontario, Canada." [See page 58.]

Mr. JAMES NEILSON (Milnbank) read "Some Notes on Scottish Carboniferous Lamellibranchiata, recently figured in Dr. Wheelton Hind's Monograph issued by the Palæontographical Society," and spoke of fossil-collecting generally in the West of Scotland. The paper was illustrated by a large series of specimens of Carboniferous Mollusca from the author's collection.

SOCIETY'S ROOMS, 207 BATH STREET, 8TH MARCH, 1900.

Mr. JOHN RENWICK, *Vice-President*, in the Chair.

Dr. CAMPBELL BROWN, M.A., D.Sc., Ph.D., of Edinburgh, gave a lecture, entitled "Notes on Famous Fossils in Continental Museums." A considerable part of his remarks was devoted to a detailed description of the fauna found in the well-known quarries at Solenhofen, Bavaria. The limestone of these quarries possesses unique properties for lithographic purposes, and is exported to all parts of the world—the number of employés being sometimes as many as 5000. These slates have long attracted the attention of the scientific world, owing to the immense importance of many of the organic remains found in them in a fossilised condition. After giving a brief historic account of the quarries at Solenhofen, some fine photographs of the workings were thrown on the screen, and the lecturer proceeded to describe the fauna in detail. Amongst the invertebrates a medusa or jelly-fish, showing every part of its structure, created great interest. Of the insects, representatives of the *Neuroptera*, *Orthoptera*, and *Diptera* were described. A fossil annelid or worm, and a kingcrao, with its footprints clearly marked in the stone, were perhaps the most noticeable of the other invertebrates. Next the vertebrates were surveyed in some detail, and, after a brief notice of the fish fauna, a considerable space was devoted to the reptiles, a large series of photographs of a curious extinct type provided with wings, and known as *Pterosaurs*, being exhibited. These extraordinary reptiles ranged in size from that of a sparrow to that of an eagle, and their wings consisted of a membrane of skin supported chiefly by the enormously elongated bones of the fifth digit of the hand. The remains of *Archæopteryx*, a bird which possessed teeth, clawed digits on its wings, and a long lizard-like tail, were next described, the only known examples of this curious creature consisting of two complete skeletons, a single feather, and some footprints. A small kangaroo-like reptile named *Campsognathus*, which belonged to the extinct order of *Deinosaurs*, from which birds are supposed to have had their origin, was shown and described. The fauna of the Upper Lias of Würtemburg, which has been derived from the quarries

Digitized by Google

at Holzmaden and Boll, was then dealt with. Two long-tailed *Pterosaurs* and two extinct marine reptiles named *Ichthyosaurus*, one of which had the skin-membrane of the fins preserved, and the other affording evidence that these creatures were viviparous, were the chief rarities described from this district. Photographs of the skeletons of gigantic marine reptiles called *Pythonomorphs*, which were thrown on the screen, appeared to approach in outward appearance the popular conception of the "sea-serpent."

The lecture was illustrated by a large and fine series of photographs displayed by the oxyhydrogen lantern. It was followed with close attention by a large gathering of members, and at its close a hearty vote of thanks was awarded to Dr. Campbell Brown for his kindness in coming through from Edinburgh to address the Society.

SOCIETY'S ROOMS, 207 BATH STREET, 12TH APRIL, 1900.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

Mr. John Wallace, 36 Hayfield Street, S.S., was elected an Associate Member.

The HON. SECRETARY (Mr. Murdoch) read a notice of the late Dr. John Young, LL.D., F.G.S., who had been a Life-member of the Society for a long period, as he joined it in 1859, the second year of its existence. During all that time, almost to within a year of his death, which took place on the 13th of March last, he had been a most active worker, and had contributed to its *Transactions* many important papers and notes, principally on subjects of Scottish palæontology, on which he had long been a leading authority. In the year 1874 Dr. Young was appointed to the post of Lecturer on Geology in the Mechanics' Institution, where he succeeded a number of distinguished teachers, including Dr. John Taylor, Mr. T. Struthers, Dr. David Page, Dr. Crosskey, and Dr. Robert Brown. He held this post till 1882, when he was appointed to a new geological lectureship which had been founded in connection with Anderson's College by Dr. James Young of Kelly. There is no doubt that Dr. John Young's labours in the teaching of geology, as well as his long-continued and unwearied work in the Hunterian Museum of the University, of which he had been under-keeper since 1859, had a most important influence on the study of the science in the West of Scotland, and that without his enthusiasm in the cause it would never have assumed the important place it has taken amongst us of late years. In 1874 Dr. Young became a member of the London Geological Society, and in 1893 he received the degree of LL.D. from the University of Glasgow, an honour which he thoroughly deserved and highly appreciated, although his friends thought it had been very tardily bestowed.

Mr. PETER MACNAIR exhibited specimens of the plates of a Fossil Fish, *Homosteus Milleri*, recently presented to the geological collection of the Corporation now in the People's Palace, Glasgow Green, by

695455

Digitized by Google

Mr. James Reid, Blairgowrie, and made some remarks upon the structure and distribution of the species.

A paper by Mr. Colin Livingston, Fort-William, entitled "Boulders and other Evidences of Ice-action in Lochaber" was read, in the author's absence, by Mr. Matthew Blair, *V.-P.* [See page 39.]

At its close some remarks were made by Mr. William Jolly, F.G.S., Mr. James Neilson, and other members, the general opinion expressed being that Mr. Livingston's observations were of great value, and that he should be asked to extend them so far as regarded those carried blocks which indicated the higher lines of the ice-transport.

SOCIETY'S ROOMS, 207 BATH STREET, 10TH MAY, 1900.

Bailie WILLIAM MACLAY, *Vice-President*, in the Chair.

The HON. SECRETARY (Mr. Murdoch) read a long and interesting letter he had received from one of the Society's very few surviving original members, Mr. Thomas M. Barr, C.E., Engineer of the Northern Division of the Caledonian Railway, giving an account of his early acquaintance and intercourse with the late Dr. John Young. It was stated, and it is interesting to note, that Mr. Barr's brother, also an original member of the Society, is still alive in New Zealand.

The CHAIRMAN (Bailie Maclay) made feeling reference to the recent death of the Duke of Argyll, an Honorary Member of the Society, who, though he had not done any actual work in connection with it, had furthered the cause of geology in many ways, and had frequently corresponded with several of the members upon geological questions.

Bailie Robert Sorley, The Firs, Partickhill, and Mr. William H. Wilson, Cross, Strathaven, were elected Ordinary Members.

Mr. JOHN SMITH exhibited specimens of *Staurocephalites serrula*, Hinde, from Carboniferous rock at Auchenskeith, Dalry, and which, so far as he knew, had not hitherto been recorded from the Carboniferous formation. In the *Quarterly Journal of the Geological Society* for August, 1880, Dr. G. J. Hinde figured and described three specimens of this fossil from the Wenlock formation of Dudley. These are furnished with from 15 to 17 nearly straight denticles, whereas the Ayrshire specimens have only 8 slightly curved denticles, and might therefore, perhaps, be put down by some geologists as a different form. In the latter there is also a wide gap between the posterior and next denticle, but in the Dudley specimens there is no such gap. The Silurian fossils measure 1·6 to 4·4 mm. in length, and the Carboniferous ones 1·7 mm.

Mr. JAMES NEILSON (Milnbank), in making some remarks on these specimens, said he objected to a Carboniferous fossil being classed under the same name as a Silurian one, and suggested that the specific name at least should be altered.

Mr. WILLIAM JOLLY, F.G.S., exhibited a series of 6-inch Ordnance Survey Maps, and a special map of the Glenroy district which he had con-

Digitized by Google

structed from the Survey sheets at the time when he was working at the geology of Lochaber. After giving some particulars about these maps, Mr. Jolly said that it gave him great pleasure to present them to the Society as a contribution towards its Map collection. He had always thought that the Society should set itself, as a special piece of work, to complete the record, and solve the great problem of the origin, nature and theory of the Parallel Roads of Glenroy. For that and other purposes it should certainly possess a full set of the 6-inch and 1-inch maps of the Geological Survey of Scotland, and that until this was accomplished he could not consider the Society was properly equipped for its work.

The handsome gift was duly accepted by the Chairman on behalf of the Society, and Mr. Jolly was awarded a hearty vote of thanks.

The HON. SECRETARY said that a beginning in the direction indicated by Mr. Jolly had lately been made, a number of the 1-inch district maps having been added to the Library, and that as they were mounted on cloth and folded in book form they were found to be useful for excursion purposes.

Mr. JOHN SMITH read "A Note on Lake-Basins being carved out of Rock by Glacier Ice." He stated that Sir A. Ramsay has generally got the credit of having originated the theory of some lake-basins having been carved out of solid rock by ice. In his well-known work on "The Physical Geology and Geography of Great Britain," page 164, he says "The theory [that lake-basins have been cut out by ice] which I propounded, is my own, and in its conception is not much more than thirteen years old" [about 1859]. In Ure's "New System of Geology," Glasgow, 1829, occurs the following passage, page 491:—"The Professor [Esmark, of Denmark] thinks this dike (moraine) could have been formed only by masses of ice (a glacier), which at one time filled up the whole valley, and by their pressure hollowed out the bottom into its series of three lakes." Sir A. Ramsay has also been forestalled by another writer, for in 1855 Mr. Henry Y. Hind suggested that the Canadian Lake Basins may have been cut out by ice. (See *Quart. Jour. Geol. Soc.*, vol. xx., page 126.) It is thus therefore evident that to Prof. Esmark must be given the credit of the theory that lake-basins may have been carved out of solid rock by glaciers, and that his observations must considerably modify the claims of subsequent writers on the action of these natural forces.

A discussion on the paper followed, some of the members maintaining that whoever might have been the first to originate it, they could not agree with the theory itself.

Mr. PETER MACNAIR gave a short account of the Society's recent excursion to the People's Palace, Glasgow. [See Notes of Excursions, page 118.]

Mr. JAMES NEILSON (Milnbank) spoke of the Society's late excursion to Nitshill. [See Notes of Excursions, page 118.]

Mr. JOHN SMITH read a note on the recent excursion of the members to Dailly in the Girvan Valley. [See Notes of Excursions, page 118.]

Digitized by Google

SOCIETY'S ROOMS, 207 BATH STREET, 31ST MAY, 1900.

Mr. JOHN RENWICK, *Vice-President*, in the Chair.

Mrs. Robert Gray, 59 George Street, Edinburgh, was unanimously elected an Honorary Member of the Society.

Mr. G. W. T. Robertson, 120 Bath Street, was elected an Ordinary Member, and Mr. A. L. du Toit an Associate Member.

The HON. SECRETARY (Mr. Murdoch) read a notice of the late Mr. James Thomson, F.G.S., an Honorary Member of the Society, and one of the very few surviving members who had joined it in its first year (1858). Largely a self-educated man, Mr. Thomson, with great natural force of character, first began the study of geology in the classes of the well-known Dr. John Taylor, of Anderson's University, a teacher whose personal enthusiasm gave such an impetus to the science about the middle of the century. An active fossil collector from the first, Mr. Thomson soon became one of the leading local authorities on the organic life-forms of the Carboniferous rocks of the West of Scotland, and on its geology, as well as on that of the Western Highlands, where his business for many years periodically led him. The group of corals more especially engaged his attention, and a special process which he personally discovered and worked for the illustration of its forms, gave very fine results. Unfortunately the details of his process do not seem to have been communicated to others, and apparently have died with their inventor. Mr. Thomson's large collection of fossil forms, numbering thousands of specimens, some years ago passed into the possession of the town of Kilmarnock through the liberality of Mr. James Dick, who, also a Kilmarnock man, was his contemporary and friend from boyhood. Mr. Dick also contributed a large sum of money for the erection of a Free Library and Museum, where the late Dr. Hunter's, and other notable geological collections, besides that of Mr. Thomson, have found an appropriate home.

The HON. SECRETARY (Mr. Murdoch) exhibited a large and striking photograph of the body of an old Chilian miner which had been recently found during the exploration of some ancient copper-workings at Chuquicamata. Being thoroughly impregnated with salts of copper, the figure was as hard as stone and perfectly preserved against decay, and the form and features were quite recognisable, as well as the hair and material of the scanty working clothing. The man had evidently been killed when at work by a fall of rock which had crushed in his ribs, and it is supposed that this took place before the Spanish occupation, about A.D. 1600. A small basket in which he had been collecting atacamite (oxychloride of copper) was still in his hands, and his stone implements were lying alongside.

[Since this photograph was shown the indurated body has been sold for a sum exceeding £1000 sterling, and is said to be destined for the United States of America.]

Mr. MURDOCH also exhibited specimens of Red Quartzite Pebbles and

Digitized by Google

Quartz Pebbles, the latter containing small patches of chlorite-schist and mica-schist. These pebbles occur frequently in the Upper Drift of Renfrewshire overlying the Boulder-clay, on the hilly ground south of Glasgow, portions of which have lately been cut through by the works of the new Lanarkshire and Ayrshire Railway. They do not appear to be present in the Boulder-clay, although fairly plentiful in the overlying bed, showing clearly that the Upper Drift is a separate deposit which was not only laid down at a later date, but that its materials were derived from a different district from those in the Boulder-clay. These pebbles mostly bear signs of crushing, and in very few instances are they found whole, nearly every one having been broken across and the sharp edges rubbed smooth, either before, or during, their transport.

Mr. JOHN SMITH read an account of the Society's recent excursion to Darvel. [See Notes of Excursions, page 119.]

An account by Mr. Goodchild, F.G.S., of the Society's excursion to Kirkcaldy and Elie, Fifeshire, was read by the Chairman (Mr. John Renwick, *V.-P.*) [See Notes of Excursions, page 118.]

Mr. JAMES NEILSON (Milnbank) read "Some Notes on a recent excursion to Ailsa Craig with members of the Andersonian Naturalists' Society." The author spoke more particularly of the geology of the island, which, he said, was composed practically of one kind of rock, now known as micro-granite. Owing to the varying proportions of its constituents in different places it assumes very varied appearances. These varieties, which are quarried for the purpose of making curling-stones, are known as "Red Hone," "Blue Hone," "Salt and Pepper" or "Ballochmyle," &c. Mr. Neilson also gave a great many interesting particulars as to the abounding bird-life of the Craig, a curious circumstance being that every year a number of birds fall off the precipitous cliffs and are killed. It is not easy to see the reason why they are not able to make use of their wings before they reach the ground below the cliff, and so escape the sudden contact which kills them.

The CHAIRMAN declared the 42nd Session to be closed, and hoped that the members present would all be able to assist at the opening of the new one in October next.

Digitized by Google

PROCEEDINGS FOR SESSION 1900-1901.

(43RD SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET, 11TH OCTOBER, 1900.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

Mr. GOODCHILD, F.G.S., of the Geological Survey, and curator of the Collections of Scottish Geology and Mineralogy in the Museum of Science and Art, Edinburgh, read a paper on "The Ballagan Beds: the Physical Geography of Great Britain during Carboniferous Times." [The substance of this paper has been printed under the title "The Lower Carboniferous Rocks of Northern Britain," see page 16.]

The paper was illustrated by a large and fine series of photographs shown by the oxyhydrogen lantern, and by diagrams and maps. At its close a hearty vote of thanks was awarded to the author.

SOCIETY'S ROOMS, 207 BATH STREET, 8TH NOVEMBER, 1900.

THE ANNUAL GENERAL BUSINESS MEETING.

Bailie WILLIAM MACLAY, *Vice-President*, in the Chair.

The HONORARY SECRETARY (Mr. Murdoch) read as follows:—

REPORT OF THE COUNCIL FOR 1899-1900.

Following the custom of previous years the Council beg now to submit to the members a *résumé* of the work and occurrences of the past twelve months—from October, 1899, to September, 1900—the 42nd year of the Society's existence.

The Membership has fluctuated but little during this period, but, though without any falling off to speak of, it certainly has not received the material additions which the Council hoped would have been the result of their repeated requests on this subject. A total ordinary membership of about 150 (that is, of course, not inclusive of honorary and corresponding members) as a representation of the interest taken in geological matters in a district so largely dependent on industrial work connected with mining, minerals and metals as Glasgow and its neighbourhood is, cannot be looked upon as a very satisfactory state of matters, and your Council think it incumbent on them even more strongly than before to urge

Digitized by Google

the members to bestir themselves and see what they can do to alter it for the better.

The Ordinary Meetings of the session were nine in number, and were held from October to May. They were all well attended, in some cases largely so, by the members and their friends. There were no special or extra meetings during the year.

The Papers read during the session were 26 in number, and were sufficient to occupy all the available time of the meetings. They were very generally accompanied by maps and diagrams explanatory of the subjects, and many of them were accompanied by photographs and drawings, which were shown on the screen by the oxyhydrogen lantern.

Specimens were frequently shown at the meetings, and were usually accompanied by explanatory notes. Such exhibits are generally of great local interest and value, and members would do well to remember that almost every one can in this way do something to contribute to the business of the meetings, and where they will be cordially welcomed.

The Excursions of the season were twelve in all, with three evening excursions. They were usually, except in the event of extremely bad weather, well attended, and some of them largely so. Embracing visits to many and widespread districts of geological interest, with the advantage to the younger members of having the salient points brought under notice by competent conductors, there is no doubt that they are not only popular, but of considerable assistance to all those members who study local geology.

The Finances of the Society will be reported on by your Honorary Treasurer (Mr. John Wight, C.A.), so no more need be said here than that the Council are satisfied they are in a satisfactory condition.

The Library, of which a report will be submitted by your Honorary Librarian (Mr. J. S. M'Lennan), has proved of use to a considerable body of the members who have found its stores of geological literature of advantage to them.

The Transactions.—No part was issued during last session, but one is now nearly all printed and will, it is expected, be ready for issue early in the coming year. [The part referred to, vol. xi., part 2, was sent out to members in April, 1901.]

Loss of Members.—During the past year the Society has experienced unusually severe losses by the death of some of its older members—Dr. John Young, F.G.S., and Mr. James Thomson, F.G.S. Notices of both the deceased gentlemen were read at meetings subsequent to their death by the Honorary Secretary, but it may here be fitly added that your Council look back with profound regret, and are sure that they are joined by every member in so doing, at the removal from amongst us of those two good friends, who had been associated with the Society from almost its commencement, and who had been greatly interested in its work during all the intervening years.

Mr. JOHN WIGHT, C.A., Honorary Treasurer, read his Financial Statement (see Abstract, page 124), and Mr. James S. M'Lennan, Honorary Librarian, gave his Annual Report (see next page).

Digitized by Google

REPORT ON THE LIBRARY FOR 1899-1900.

Your Librarian has to report that during the past year 42 readers took out 200 volumes to consult or read.

The additions made to the Library were somewhat small—some six volumes—as few new geological works were published. It is to be hoped that a larger number may be obtainable during the current year.

The *Transactions* and *Proceedings* of 28 British, 14 Colonial, and 17 American Scientific Societies—50 in all—have been received from their respective Societies during the year, as well as about 22 pamphlets, the gifts of their authors.

The various *Transactions*, &c., of 22 Foreign Scientific Societies received in exchange during the year have been transferred to the Mitchell Library. The languages were French, German, Italian, Russian, Swedish, and Spanish (South American).

On the motion of the Chairman, seconded by Mr. Wm. Jolly, F.G.S., these Reports, showing a healthy state of the Society's work and prospects, were unanimously approved.

Mr. William Armour, C.E., moved a hearty vote of thanks to the Honorary Secretaries (Mr. J. B. Murdoch and Mr. G. M. Pratt), Treasurer (Mr. John Wight, C.A.), and Librarian (Mr. James S. M'Lennan) and this was unanimously agreed to. Mr. Armour also asked for a special vote of thanks to the Assistant Hon. Secretary (Mr. Pratt), who was retiring, he was sorry to say, from the post which he had held with so much acceptance for a long series of years. The intimation was received by the members with regret, and the vote of thanks to Mr. Pratt for his long-continued services was cordially agreed to.

The Chairman announced that Mr. Peter Macnair, Curator of the Green Branch Museum, People's Palace, had been chosen by the Council to fill the vacancy caused by Mr. Pratt's retirement from the Assistant Secretaryship, and he was sure the appointment would be approved.

The following gentlemen were elected to fill the vacancies occurring at this time in the Council:—

As Vice-President, Mr Robert Kidston, F.G.S.; as Members of Council, Messrs. John Renwick, James Steel, James Stark, and David Nimmo, all for a period of three years.

Mr. Joseph Sommerville moved a vote of thanks to the retiring office-bearers for their past services to the Society, which was seconded by the Chairman and unanimously agreed to.

The following gentlemen were elected Members of the Society:—

As a Life Member—Mr. M. M. Graham, 21 Bath Street.

As Ordinary Members—Mr. William Bannerman, 21 Glencairn Drive, Pollokshields; Mr. Thomas Begg, Elms, Mount Vernon; Mr. George M. Cathcart, 2 Colebrooke Street, Hillhead; Mr. Andrew C. Mann, 30 Lansdowne Crescent; Mr. William Martin, 4 North Court, Royal Exchange; and Mr. James Moffat, 35 Gardner Street, Partick.

Digitized by Google

Mr. JOHN RENWICK exhibited a specimen of Pectolite, from Lendalfoot, near Girvan, Ayrshire, which had been found by Mr. Thomas Wilson, Ayr, and made some remarks upon the occurrence of the mineral in Scotland. At this locality, from which specimens had been obtained by the late Dr. Heddle and analysed by him, it sometimes shows white fibro-crystalline radiations of nearly three feet in length.

Mr. P. MACNAIR read a paper by Mr. J. B. Murdoch and himself, entitled "Notes on a New Section of the Orchard Limestone South-west of Giffnock, and on Outcrops of the Neighbouring Limestones." The object of the paper was to bring before the members the discovery of a new locality for the Orchard limestone, of which a section had recently been exposed in one of the cuttings for the new Lanarkshire and Ayrshire Railway at Whitecraig, close to the Kilmarnock Road, about a mile south-west of Giffnock. This section was not only interesting in itself, but was noteworthy from the fact that it entirely corroborated the views expressed by Captain Stewart of Williamwood in a paper he had read before the Society, "On the Limestones of the Parishes of Cathcart and Eastwood, Renfrewshire," in 1881.* In that paper the author controverted the views which had been published by the Officers of the Geological Survey as to the position of the Orchard limestone in the district, and mapped it out in a direction which would bring it almost exactly to the position where it has now been exposed. He also showed the existence of an extensive seam—the Holeburn limestone—which had not been recorded at all in the Survey Maps and Memoirs. The new exposure of the Orchard limestone, with its accompanying shale, cannot be called highly fossiliferous, as were the old exposures at Orchard farmhouse, near Giffnock Station, which for many years formed one of the principal "happy hunting-grounds" of the older generation of Glasgow geologists—John Young, James Thomson, James Armstrong, and many others. It was stated that the present paper was preliminary to a more extended one, which the authors hoped to lay before the Society on a future occasion.

The paper was illustrated by diagrams.

Mr. JAMES S. M'LENNAN, Hon. Librarian, read a paper "On the Geology of Portrush," the result of observations made during a visit in July, 1900. In the course of his remarks the author enumerated and described the various rock-formations of the district, speaking more particularly of the basalts with their columnar structure, which occurs in its most prominent forms in the well-known "Giant's Causeway." The phenomena there, and the accompanying problems, were described in detail, and the paper was brought to a close by the poet's appropriate word-picture, as follows:—

"This far projecting, firm, basaltic way,
Of clustering columns wedged in dense array;
With skill so like, yet so surpassing art,
With such design, so just in every part,
That reason pauses, doubtful if it stand
The work of mortal or immortal hand."

* *Trans.*, vol. vii., part 1, 1883.

Digitized by Google

SOCIETY'S ROOMS, 207 BATH STREET, 13TH DECEMBER, 1900.

Mr. ROBERT KIDSTON, *Vice-President*, in the Chair.

Mr. JAMES NEILSON (Port-Dundas) moved that a sum not exceeding £10 of the Society's funds be devoted to Library purposes during the current session. Mr. Joseph Sommerville seconded, and the motion was unanimously approved.

The following gentlemen were elected members:—

As Life Members—Mr. Samuel F. Cozens, Salem, Skelmorlie; and Mr. John Muirhead, 13 St. John's Drive, Pollokshields.

As Ordinary Members—Mr. Richard C. Farrell, C.E., 15 Hope Street; and Mr. James T. Forgie, M.I.M.E., Viewfield, Bothwell.

As Associate Members—Mr. Donald F. Forbes, Student, 186 Henderson Street; Mr. James Love, Teacher, Kibble Institution, Paisley; Mr. Peter Mackenzie, Apprentice Joiner, 286 West Princes Street; Mr. William MacPheat, Student, Abbey Green Manse, Blantyre; Mr. A. F. Midgeley, Clerk, Ebonville, Cambuslang; Mr. F. J. Richards, Engineer, 8 Wilton Mansions, Kelvinside, N.; Mr. Frank Sproule, C.E., c/o Mrs. Clothworthy, 76 Stevenson Drive, Shawlands.

Mr. J. B. MURDOCH, Hon. Secretary, exhibited a specimen of the sandstone layer above the recently exposed section of the Orchard limestone and shale at Whitecraig, near Giffnock, on the line of the new Lanarkshire and Ayrshire Railway, which contained quantities of annelid casts, or, as some observers pronounced them to be, plant-remains. He also gave some notes on the recent visit of the Society to the section, and stated that it was just in time, as already a large part of the limestone seam had been covered in by the concrete wall for the station platform, though on the north side of the cutting it was still open for inspection.

A paper by Mr. JOHN SMITH, entitled "Notes on the Cuttings of the New Railway from Banavie to Mallaig," being an account of the Society's excursion on June 23rd last, was read by the Hon. Secretary (Mr. Murdoch). (See "Notes on Excursions," page 120.)

A number of photographs taken on the occasion of this trip on the Mallaig Railway were exhibited on the screen by the oxyhydrogen lantern.

In further illustration of Mr. Smith's paper Mr. JOHN RENWICK exhibited a number of specimens of the rocks met with during the excursion, and made some remarks on their occurrence.

Mr. JAMES STIRLING, Government Geologist to the Colony of Victoria, who was present at the meeting, made some remarks upon the similarity of a number of these Highland rocks to those of the Australian colonies.

Mr. MATTHEW BLAIR, *Vice-President*, read a paper entitled "Some Speculations on Surface Geology." He stated that the sections of the older rock-formations were often difficult to be reached, but that could not be said of the surface-deposits, which were always easy of access and available for study. The accumulations of gravels, sands, and clays, with which the face of the country is covered, are so easily disturbed and confused, or even obliterated, that any deductions made from their

Digitized by Google

appearances has to be done with great caution, and even where reliable could only show the most recent changes to which the deposits have been exposed. The present contours of the hills and valleys were carved by running streams out of a plain of denudation of uncertain height, but from the shape of the western lochs and valleys the sea-line appears to have been at that time some 300 feet lower than it now is. The author said he thought this tableland existed in Tertiary times, one proof being that afforded by the trap-dykes of Arran which are found piercing the lofty hills to a height of 3000 feet without showing any signs of having ever reached the surface. This denudation and excavation continued through all Tertiary times, and the debris and materials worn and torn off went to form the great bank which surrounds Scotland seawards as far out as the 100-fathom line, beyond which the sea-bottom deepens rapidly. In more recent times the surface-deposits clearly indicate that there was a rapid submergence and re-emergence of the land, coincident with the advance of the ice-age. But not till the extreme glacial conditions had passed away did the land rise, the weight of the accumulated ice being, perhaps, one cause of the continued depression. All these changes of level were testified to by the position and character of the surface-deposits as we now find them, as well as those of the sea-beaches and deltas.

The paper was illustrated by a fine series of photographs of the more prominent features referred to in it, which were thrown on the screen by the oxyhydrogen lantern.

SOCIETY'S ROOMS, 207 BATH STREET, 10TH JANUARY, 1901.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

On the motion of Mr. William Armour, seconded by Mr. Neilson (Port Dundas), Messrs. J. R. M'Farlane and David Pearson were appointed Auditors for the current year.

The following gentlemen were elected members:—

As Ordinary Members—Mr. A. V. Lothian, M.A., B.Sc., Science Lecturer, Established Church Training College; Mr. A. M'Culloch, 163 West Regent Street; Mr. W. H. Scott Mackirdy of Birkwood, Lanarkshire; Mr. William Morton, Cairntable, Newlands; and Mr. John Wallace, 36 Hayfield Street.

As Associate Members—Mr. C. S. Alston, 563 Great Eastern Road; Mr. W. J. N. Dunnachie, Newlands, Mount Vernon; Mr. A. M. Ferguson, C.E., M.E., Acacia Villa, Bonhill; Mr. John Gibb, Luggie View, Kirkintilloch; Mr. William Mason, Fielden Weaving Co., Bridgeton; Mr. D. M'Bride, 44 West Bothwell Street; Mr. G. H. M'Cowan, C.E., 8 Regent Park Square, Strathbungo; Mr. J. M. Stewart, 317 Onslow Drive; Mr. R. Strachan, 30 Rae Place, Main Street, Shettleston; Mr. T. Young, 33 Meadowpark Street; Mr. J. G. Brown, 168 Holm Street; and Mr. R. M. Thompson, 34 Hill Street, Garnethill.

Digitized by Google

Mr. R. W. Dron, C.E., M.E., read a paper entitled "The Carboniferous Limestones of Scotland, with their Coals." [See page 66.]

The paper was illustrated by a series of geological maps. At its close, an interesting discussion was taken part in by Messrs. James Neilson (Milnbank), Peter Macnair, G. R. Thompson, and the Chairman.

Mr. James Stark read a paper on "The Shore Section at Portincross, Ayrshire." [See page 74.]

The paper was illustrated by maps and sections, and at its close a discussion was taken part in by Messrs. James S. M'Lennan, James Neilson (Milnbank), J. B. Murdoch, and other members.

Society's Rooms, 207 Bath Street, 14th February, 1901.

Mr. Matthew Blair, *Vice-President*, in the Chair.

The Honorary Secretary (Mr. Murdoch) read, on behalf of Mr. John Smith and himself, a long and appreciative notice of the late Mr. Robert Craig of Beith, who had been for many years a member of the Society, and a considerable contributor to its *Transactions*. The deceased was an accomplished local geologist, a Burns student, and a poet, and all who had the privilege of his friendship feel the poorer by his death.

Mr. William Jolly, F.G.S., said he could corroborate all that was stated in the notice of their friend, Mr. Craig. Many years ago he had been introduced to him by their mutual friend Dr. John Young, when they were on an excursion between Beith and Dalry. His removal was not only a great loss to his friends, but a greater one to geological science.

It was agreed that the Hon. Secretary should write to Mr. Craig's nephew, his nearest of kin, expressing the regrets of the Society at Mr. Craig's death.

The Hon. Secretary read also a notice of the late Mr. James Bennie, of the Geological Survey, who had been a member of the Society since 1859, the second year of its existence. For a long period of time, while resident in Glasgow, Mr. Bennie had worked during his very scanty leisure hours, principally at the local surface-geology, to such good purpose that he became an acknowledged authority regarding it. In 1869 he received the appointment of Fossil Collector to the Geological Survey, and he then removed to Edinburgh. Some time after this he took up the study of micro-organisms in the Carboniferous rocks of Central Scotland, and the result was his discovery of many forms new to science. He was the first to detect the remains of Arctic plants in the silts and peats deposited and preserved in the beds of ancient lakes in the Scottish Boulder-clays.

The Hon. Secretary also read a long letter he had received from Mr. Bennie's eldest son, giving some interesting facts in his father's life, and it was agreed that an expression of the great regrets of the Society at Mr. Bennie's death should be sent him.

Digitized by Google

Mr. R. W. Dron, C.E., M.E., exhibited a number of fine photographs of the Glaciers of Illecillewaet, on the Selkirk mountain-range of British Columbia, at an elevation of from 4500 to 6000 feet. This district was entirely unknown to white men before 1883, and even then the Indians had seldom or never visited it owing to some superstitious fears. It is therefore quite probable that the engineers surveying for the Canadian Pacific Railway in that year were its first real explorers. But the advent of the iron horse changed all that, and as there is now a railway station within a mile and a half of the glacier it is exceptionally easy of access. The extent of the névé or snowfield which feeds it and several other glaciers is probably from 300 to 400 square miles. The glacier itself is about a third of a mile wide and three miles long, with an average surface-slope of 22 degrees. Careful observations, taken at the Glacier House Station from October, 1898, to May, 1899, show a total snowfall of 43 feet 8½ inches. The rate of flow of the glacier has been accurately measured by means of fixed plates and trigonometrical observations, taken from 1st July to 5th September, 1899, representing the maximum midsummer flow, show that near its centre the rate of daily progression was from 6 to 7 inches, and near the side averaged 2½ inches. In common with most of the other glaciers in North America, the Illecillewaet glacier is evidently melting at a greater rate than is compensated for by the supply of ice from its feeding grounds, and the measurements show that during the last twelve years it has been receding at the average rate of 56 feet per annum.

Mr. James S. M'Lennan, Hon. Librarian, exhibited a number of Fossil Shells from the Island of Labuan, and made some remarks upon their occurrence. The rock in which they were found appeared to be of a later date than the Carboniferous formation, but as yet it had not been definitely identified.

Mr. John Wallace read a paper, entitled "Notes on a Recent Excavation in Sauchiehall Street, with the Journals of the Bores." [See page 79.]

The paper was illustrated by diagrams and specimens, and at its close remarks upon the great value of such local observations were made by Mr. James Anderson and the Chairman.

Mr. Peter Macnair, Assist. Hon. Secretary, read a paper, entitled "Notes on the Production of 'Ausweichung' or Strain-slip in Schistose Rocks." [For a Summary see page 89.]

The paper was accompanied by a series of rock-specimens, and by a number of sections which were shown under the Society's microscope.

Mr. James Neilson (Milnbank) read a paper on "The Jurassic and Liassic Rocks of the Yorkshire Coast-line." In the course of his remarks the author fully described the Oolite of Scarborough, and then discussed the glacial and other phenomena shown in Robin Hood's Bay. He remarked upon the apparent absence of striated blocks in the Boulder-clay there, and that there did not seem to be any Raised-beaches like those so well marked on the Scottish coasts. There appeared to have been a considerable alteration of the coast-line in this locality through denuda-

Digitized by Google

tion. In conclusion he gave a graphic description of the Lias beds exposed in the neighbourhood of Whitby, and their interesting characteristic fossils, the importance of whose zonal value he pointed out.

The paper was illustrated by a large series of specimens of fossils from the rocks under review, many of those of the cephalopods being cut and polished to show their interior structure.

SOCIETY'S ROOMS, 207 BATH STREET, 14TH MARCH, 1901.

Bailie WILLIAM MACLAY, *Vice-President*, in the Chair.

Mr. William Hunter, Rosemount, Ledard Road, Langside, was elected an Ordinary Member of the Society; and Messrs. George Howie, Clydeside Cottage, Uddingston, and Frederick Mort, Viewfield, Partickhill, Associate Members.

Dr. R. H. TRAQUAIR, LL.D., F.R.S., F.G.S., Keeper of the Natural History Collections in the Museum of Science and Art, Edinburgh, read a paper "On Fish Remains collected by Messrs. P. Macnair, J. Young, E. White, and A. White, in the Silurian Rocks of Lanarkshire."

In the course of his remarks the lecturer said that though no new species had been detected in the course of the explorations by the gentlemen named during the last two years, some very good specimens of these species already described from the locality, belonging to the genera *Thelodus*, *Lanarkia*, *Ateleaspis*, *Birkenia*, and *Lasanius*, had been found. In some of these the configuration of the scales was extremely well shown. The author concluded an interesting paper by pointing out the great light which those comparatively recent discoveries in the Silurian rocks of Southern Scotland, made first by the Officers of the Geological Survey, had thrown on some of the obscure problems in fossil ichthyology.

A description of some new Crustaceans, discovered last year by Mr. Peter Macnair, in the Upper Silurian "Inlier" of Lesmahagow, was given by Mr. MALCOLM LAURIE, D.Sc., F.R.S.E., Professor of Zoology in St. Mungo's College. As yet their exact affinities had not been ascertained, and consequently they had not been named, but they probably belong to a group intermediate between the Phyllopoda and the Phyllocarida. Of their interesting nature there is no question, and it is to be hoped that further explorations in the same beds may yield other and better-preserved specimens, so that the doubtful points may be cleared up.

The paper was illustrated by drawings of the organisms.

Mr. PETER MACNAIR read a graphic descriptive account of the "Life in Camp Siluria," as the local habitation of the enthusiasts, who for the two previous summers had spent some months under canvas on the upper waters of the Clyde, was happily designated. There they spent the time industriously "howking" for the fish-remains, of which the Silurian rocks of the Upper Lanarkshire district contain notably fine examples. The original idea of camping-out was due to a member of the Society, Mr. David Nimmo, and without his efficient aid it could hardly have been the success

Digitized by Google

it turned out to be. In the summer of 1899 "the pitch" was made on the banks of the Logan Water, where the late Dr. Hunter did some notable collecting work, above Logan House, while in 1900 the tent was transferred to the small valley of the Birkenhead Burn in the same neighbourhood. In the summer of 1901 it was intended to organise another expedition to the locality, and it was hoped and expected that the efforts of the geologists then assembled would be even more successful than those of previous years in discovering specimens of fish and crustacean remains as yet undescribed or very rare.

SOCIETY'S ROOMS, 207 BATH STREET, 11TH APRIL, 1901.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

Mr. CHARLES R. COWIE read a paper, entitled "Notes on the Shoals at Caticol Point and Kirn Point, Arran." The author explained that in the course of his investigations last year in the locality named he had discovered that nearly all the boulders at Caticol Point, and many at Kirn Point, were quartzites, conglomerates, and fossiliferous limestones, and not, as hitherto supposed to be the case, granites or clay-slates. They must, therefore, have been carried by the ice from the north end of the island to the place where they were deposited under the shelter of the above-named tongues of land.

The paper was illustrated by a large series of specimens of rocks, and by a number of photographs shown by the oxyhydrogen lantern. At its close remarks on various points raised were made by Messrs. Macnair, Sommerville, Armour, and the Chairman.

Mr. J. B. MURDOCH (Hon. Secretary), showed by the oxyhydrogen lantern some photographs of well-known members of the Society lately deceased:—Dr. John Young, F.G.S.; Mr. James Thomson, F.G.S.; Mr. James Bennie, Mr. E. A. Wünsch, and Mr. Robert Craig.

Mr. MURDOCH also showed some lantern slides from photographs of views taken by his son in the mining region of Yanamina, in the Cordilleras of Peru, at an elevation of over 15,000 feet, and gave some particulars of their geological features.

Mr. MURDOCH also read "A Few Notes on the Recent Excursion of the Members to Giffnock." (See "Notes on Excursions" in the next part.)

Mr. DAVID NIMMO read a short "Account of the Society's Excursion to Colintraive, Kyles of Bute," which had been made on the late Spring Holiday under very inclement weather conditions. (See "Notes on Excursions" in the next part.)

SOCIETY'S ROOMS, 207 BATH STREET, 9TH MAY, 1901.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

Mr. William Forsyth, Muir Street, Hamilton, was elected an Ordinary Member of the Society.

Digitized by Google

Mr. JAMES STEEL read a short memorial notice of the late Mr. James White, who had been long an active member of the Society, and for many years had acted as its Hon. Librarian.

Some remarks on Mr. White were also made by Mr. William Armour, the Chairman (Mr. Blair), and Mr. Murdoch (Hon. Secretary), who was asked to write to Miss White expressing the regrets of the members at her father's death.

Mr. DAVID NIMMO exhibited a large and fine collection of Eocene fossils from Highcliffe and Barton, in Hampshire, the shells being in the highest state of preservation.

The CHAIRMAN (Mr. Blair) read a paper on "The Drainage of the Nile Valley." (For a summary see page 90.)

The paper was illustrated by maps, specimens, and by a large series of photographs which were displayed by the oxyhydrogen lantern.

Mr. R. W. DRON, C.E. and M.E., gave an account of the Society's recent Excursion to Provan Gasworks, to inspect cuttings lately made there in the Boulder-clay and the underlying Millstone Grit. (See "Notes on Excursions" in the next part.)

On behalf of Mr. GOODCHILD, F.G.S., of the Geological Survey, the Hon. Secretary, Mr. Murdoch, read an account of the Society's late Excursion to Arthur's Seat, Edinburgh, jointly with the Edinburgh Geological Society. (See "Notes on Excursions" in the next part.)

In illustration of the paper Mr. S. FINGLAND showed, by means of the oxyhydrogen lantern, a large number of photographs of the geological phenomena, which had been taken by himself.

SOCIETY'S ROOMS, 207 BATH STREET, 30TH MAY, 1901.

Bailie WILLIAM MACLAY, *Vice-President*, in the Chair.

The following gentlemen were elected Ordinary Members :—Mr. John Faill, Winton Drive, Kelvinside; Mr. A. Campbell Barron, Medical Practitioner, Woodbank House, Dailly; Mr. Malcolm J. Finlayson, B.A., Headmaster, Burgh School, Girvan; Mr. E. W. Gemmell, Board of Trade Surveyor, 1 Valeview Terrace, Langside; Mr. Robert Marshall, Headmaster, Parish School, Friedensheim, Girvan; Mr. Walter Scobie, Miner, Brunston Cottages, Dailly. And as an Associate Member—Mr. William Kyle, 55 West Regent Street.

Mr. GEORGE R. THOMPSON exhibited a series of specimens of rocks obtained at the Society's excursion to Rankinston and Dalmellington, Ayrshire, and made some remarks on their occurrence.

Mr. JOHN SMITH read a paper on "The Geology of the Elvanfoot to Wanlockhead Railway (with Special Reference to the Drift)." (See page 81.)

Digitized by Google

EXCURSIONS FOR THE SEASON OF 1899.

To the People's Palace, Glasgow Green, on Saturday, 18th March,—Mr. George R. Thompson, conductor. The object of the excursion was for the purpose of inspecting the "Glen" collection of rocks and minerals which, formed by the late Mr. D. C. Glen, long a member of the Society, had recently been acquired by the Corporation. The party was met by Mr. G. W. Ord, curator of the Museum, who drew attention to many of the fine specimens in the cases, and explained the method he had adopted in their arrangement. The specimens are placed in numerical order, with a printed index to the numbers in each. Case I. has a fine selection of glass models of crystals illustrating all the simpler forms. Case II. forms an index to the whole collection, and all the other cases contain merely an amplification of the specimens in this one.

To Callander, Perthshire, on Monday, 3rd April (the Glasgow Spring Holiday), Mr. Peter Macnair, conductor—a joint excursion with the Natural History Society of Glasgow. The phyllites, grits, and greywackes of Loch Lubnaig and the Pass of Leny were first visited, then the limestones and shales of supposed Arenig age at Kilmahog quarry in the grounds of Leny House, and afterwards the conglomerates of Old Red Sandstone age, and the sandstones and shales on Keltie Water. The excursion concluded with a visit to the Falls of Bracklinn. The party had tea at Callander. The total walk was about 7 miles.

To Dumbuck, Dumbartonshire, on Saturday, 8th April, Messrs. William Armour and W. A. Donnelly, conductors—a joint excursion with the Glasgow Philosophical Society. The rocks of the Calciferous Sandstone series were first visited, and there was an inspection of an interesting volcanic neck of basalt and agglomerate of Lower Carboniferous age, also a Tertiary basalt dyke, and a Raised-beach bed. The well-known crannog at Dumbuck on the shore of the Clyde was afterwards visited and its salient features explained by Mr. Donnelly, its discoverer. The total walk was under 4 miles.

To Falkirk and Camelon, Stirlingshire, on Saturday, 22nd April, Mr. John Renwick, V.P., conductor—a joint excursion with the Edinburgh Geological Society, and the Glasgow Archæological Society. After the arrival of the large party at Falkirk they visited the Parish Church, and inspected its many interesting features. They then proceeded to Bantaskine House with its fine trees, and from thence to Camelon where the members went over the extensive excavations which had recently been made on the site of the great Roman station there. Mr. MacLuckie, F.S.A.Scot.,

Digitized by Google

of Falkirk, explained the archæological features, and Mr. B. N. Peach, F.G.S., of the Geological Survey, gave a short address on the surface-geology of the district, including some fine examples of kames, river terraces, &c. In returning a number of the party walked along the line of the Roman Wall, and others visited the grounds of Callendar House. The walk ranged to from 4 to 6 miles.

To Neilston and Barrhead, Renfrewshire, on Saturday, 29th April, Mr. James Anderson, conductor. A very small party turned out on this occasion, the weather conditions being very unfavourable. At Neilston it was met by Mr. John Mackie, Dr. Pryde, and Mr. Dunlop. At a point on the new railway works, about 1 mile west of Neilston, where the face of a cliff has been cut into, a considerable extent of ash-beds beneath the overlying trap has been exposed, but not sufficiently to reach below the portion affected by weathering. From this place eastwards the railway runs largely through Boulder-clay and surface-beds, so that little of interest has been laid open, though it has followed remarkably closely the line of fault marking the division between the Carboniferous rocks to the north and the volcanic rocks to the south. The distance walked extended to about 6 miles.

To Glenbuck, Ayrshire and Lanarkshire, on Saturday, 6th May, Mr. B. N. Peach, F.G.S., of the Geological Survey, conductor, — a joint excursion with the Edinburgh Geological Society. After the arrival of the party at Glenbuck station, the Ludlow and Downtonian divisions of the Silurian rocks were visited, amongst them being the strata which contain numbers of fish-remains as recently discovered by Officers of the Survey. There were also seen the conglomerate of the Lower Old Red Sandstone, an anticline and thrust fault, and a good example of a Tertiary dyke. The party had tea at Douglas, and then returned by train to Glasgow. The distance walked was under 5 miles.

To Kirkconnell and New Cumnock, Dumfriesshire and Ayrshire, on Thursday, 18th May (the Queen's Birthday holiday), Mr. John Smith, conductor. The Craigdullyeart limestones of the Calciferous series were inspected, also the coal-beds. A visit was made to the shales containing estuarine fossils belonging to the Carboniferous system, which are exposed on the Muirfoot burn. Tea was had at New Cumnock, whence the party returned by train to Glasgow. The distance walked was about 10 miles.

To North Berwick, East Lothian, on Saturday, 3rd June, Mr. Goodchild, F.G.S., conductor—a joint excursion with the Edinburgh Geological Society. In the course of their walk along the sea-cliffs showing a fine coast section of Lower Carboniferous tuffs, with intrusive dykes and sheets, and inter-stratification of rocks of sedimentary origin, the members found a number of minerals, — analcime, natrolite, celestine, göthite, amethyst, chalcedony, dolomite, &c. They then proceeded to Tantallan Castle, where they inspected the picturesque ruins, and afterwards proceeded to Canty Bay where they had tea. The total walk was about 7 miles.

Digitized by Google

To Burn Anne, Galston, Ayrshire, on Saturday, 17th June, Mr. John Smith, conductor. This locality has long been famous for its chalcedonies, known as "Burn Anne pebbles" from the stream on whose banks the exposure of andesite which contains them lies. They are now, however, very scarce and difficult to find. Some fine exposures of coal-beds were seen. The distance walked was under 3 miles.

To Innellan and Dunoon, Argyllshire, on Saturday, 5th August, Mr. Joseph Sommerville, conductor, a joint excursion with the Natural History Society of Glasgow. The object was to inspect the shore sections exposed between the two places named above. A short way south of the Innellan Pier a fault has thrown down the Upper Old Red Sandstone which still exists on the shore between this point and Toward. The first post examined was a crush-breccia of green serpentine, the blocks running up to 9 or 10 inches in diameter. Many beds of metamorphosed sedimentary schists, now known as phyllites, were passed over on the shore going Dunoon-wards, and these were seen to be intercalated with metamorphosed limestones. The schists are frequently by basalt dykes, running N.N.W., and these pass up to and in some cases cut through the broad dyke which runs from east to west across Scotland as far as Loch Fyne, and which is well seen at Dunoon, where its exposure is known as the Castle Hill. The walk extended to about 4 miles.

To the Falls of Clyde, Lanarkshire, on Saturday, 19th August, Mr. James Stark, conductor, a joint excursion with the Edinburgh Geological Society. Members walked from Lanark station to the Falls of Corra Linn, and Bonnington, and the salient features of the splendid example of the post-glacial river-gorge through which the Clyde now runs at this part of its course were inspected, as well as that of the old pre-glacial channel now buried deeply under the surface-beds. Some fine sections of Lower Old Red Sandstone rocks were seen, also of river eskers. The distance walked extended to about 4 miles.

To Cowal, Argyllshire, on Saturday, 2nd September, Mr. W. C. Crawford, President of the Edinburgh Field Naturalists' and Microscopical Society (with which this was a joint excursion), conductor. The party landed from the Lochgoilhead steamer at Ardentinny, whence they walked to Blairmore inspecting the metamorphic schists, with an anticline of foliation, the basalt dykes, and on the sea-shore about half-tide mark the Clyde glacial shell-beds.

EVENING EXCURSIONS IN 1899.

To Giffnock, Renfrewshire, on Thursday evening, 8th June, Mr. Peter Macnair, conductor. The fine exposures of the Carboniferous Sandstones in the well-known quarries at this place were visited, and in the spoil-heaps some good examples of plant-remains were found.

To Robroyston, Lanarkshire, on Thursday evening, 22nd June, Mr. R. W. Dron, conductor, and an inspection of the Boulder-clay section there was made.

Digitized by Google

EXCURSIONS FOR THE SEASON OF 1900.

To the People's Palace, Glasgow Green, on Saturday, 10th March, Mr. Peter Macnair, Keeper of the Green Branch Museum, conductor. After meeting in the Museum the party were conducted over the various rooms where the geological collections are displayed, and many of the fine specimens—mineralogical and palæontological—acquired as part of the "Glen Collection," attracted deserved attention. When the varied material which has already come into the possession of the Corporation is transferred to the New Galleries at Kelvingrove the city will be found to be richer in geological specimens than most of its inhabitants are at present aware of.

To Nitshill, Renfrewshire, on Saturday, 31st March, Mr. James Neilson (Milnbank), conductor. From the station at Nitshill, close to which the spoil-heaps of the neighbouring coal and ironstone pits were inspected, the members proceeded to Darnley, where they went over the cement-works of Mr. A. Kirkwood. At the opencast quarries where the Arden cement limestone is worked for this purpose the accompanying shale is in some places fossiliferous, and collectors of the party were able to secure some good specimens. From this point the members proceeded to the new Lanarkshire and Ayrshire Railway works to the south, where some fine sections of Boulder-clay were seen, with numerous scratched stones, mostly local, though a few were travellers, from as far distant as the West Highlands. The distance walked was about 5 miles.

To the Girvan Valley, Ayrshire, on Monday, 16th April (the Glasgow Spring Holiday), Mr. John Smith, conductor—a joint excursion with the Natural History Society of Glasgow. The Glasgow and South-Western Railway train leaving St. Enoch Station at 8.40 a.m. made a special stop for the party at Dailly. From thence under Mr. Smith's guidance they proceeded to visit in succession Rough Neuk, Quarrelton, and Drummuck quarries, thus inspecting sections belonging to the various Silurian divisions—Lower Llandovery, Caradoc, Arenig, and Llandeilo—some of the rocks being very fossiliferous. Dalquharran House was afterwards visited, and some fine specimens of trees were seen. Mrs. Robert Gray, well known amongst geologists for her splendid collection of fossils from the Ayrshire Silurian rocks, was present during part of the day. After tea at New Dailly, the members returned to Glasgow. The distance walked was about 6 miles.

To Seafield, Kirkcaldy, Fifeshire, on Saturday, 28th April, Mr. Goodchild, F.G.S., of the Geological Survey, conductor—a joint excursion with the Edinburgh Geological Society. After leaving the "lang toun," and reaching the seashore, it was pointed out that near the Tyrie Bleach-works shells of the types prevalent in the Clyde glacial beds had been found a few years ago when excavations were made, and it was explained that the deposit was probably one of the deeper-water equivalents

Digitized by Google

of the older Raised-beaches. Then the rocks exposed here at low tide, which belong to the upper part of the so-called Edge-coal series, and which were formerly known as "The Lower Coal-measures," were inspected. At Seafield Tower the very marked false-bedding of the sandstones was noticed, and their very red colour, due to their having received solutions of iron from the Trias. South of this were seen a number of beds of limestone which come to the surface and are followed by basic eruptive rocks. A fine vein of göthite accompanied by hematite which had replaced calcareous matter. Mr. Goodchild said he believed that the iron ores were replacement-products due to the infiltration of the Trias which at one time covered these parts. An interesting set of marine limestones—one of the well-known Hurlet limestone series—was next studied, and was found to be associated with tuffs and basic eruptive rocks, undoubtedly lava-flows. With these were interstratified some thin beds of sandstone and shale of shallow-water origin, amongst them being three "bone beds" crowded with fragmentary remains of the teeth, scales and bones of Lower Carboniferous fishes. From this point the party strolled past the almost interminable series of basalt lavas, tuffs, and intercalated marine strata, so well seen on the Abden shore. They had tea at Kinghorn. The distance covered in the walk was about 5 miles.

To Darvel, Ayrshire, on Saturday, 12th May, Mr. John Smith, conductor, the object being to examine the cuttings now in course of making for the new railway to connect Darvel with Strathaven. Many interesting sections were examined, but perhaps the finest of them was one about two miles east of Darvel and about 500 feet above sea-level. This showed (*a*) stratified sand; (*b*) Boulder-clay, with many stratified patches and sea-shells; (*c*) laminated clay with large striated blocks and sea-shells; and (*d*) Boulder-clay. It seemed to be pretty certain from the evidence that these beds containing sea-shells had been deposited in water, and that they had not been since moved from the same position. Besides the railway-cuttings Loudoun Hill was also visited. The distance walked was about 6 miles.

To Elie, Fifeshire, on Thursday, 24th May (the Queen's Birthday Holiday), Mr Goodchild, F.G.S., conductor—a joint excursion with the Edinburgh Geological Society. Just east of Elie Harbour the following section was seen—blown sand, marine peat, tough clay with small stones (including flint and chalk fragments of Danish type, also gneissose and other rocks of foreign facies) and molluscan remains identical with recent Spitzbergen species. Thus the whole bed was of much more Arctic type than the well-known Post-pliocene beds of the Clyde. At Elie Ness some splendid sections of volcanic necks were seen, mostly filled with agglomerate —consisting of both volcanic and sedimentary rock-fragments. Many of the latter were stained Carboniferous rocks, apparently of later date than the New Red. This agglomerate also contained many ejected fragments of pyrope (known as "the Elie garnet"), soda microline, very fresh hornblende, and biotite in large plates. The occurrence of these minerals

Digitized by Google

makes it probable that the volcanoes here had made their way to the surface through some older crystalline rocks, and also through metamorphic rock at no great distance below the surface. The size of these necks varies greatly, one is nearly half-a-mile across, and another only ten feet by seven. Some very interesting examples of white trap were seen, all as usual associated with carbonaceous deposits. Sandstone, including much secondary quartz, and another variety, stained with concentric shells of limonite gave rise to some discussion. The party afterwards crossed the golf-links and had tea at Elie, whence they took train for Edinburgh and the West. The distance walked extended to about 6 miles.

To Logan Water, Lesmahagow, Lanarkshire, on Saturday, 9th June Mr. Peter Macnair, conductor—a joint excursion with the Edinburgh Geological Society. (From the absence of Mr. Macnair through illness the party was led by Mr. D. Tait of the Geological Survey.) Driving from Birkenhead, after arrival of the train at Lesmahagow, an examination was first made of the fine exposures in the burn of the Downtonian rocks, showing the conglomerate with large quartzite pebbles, the green and red mudstones with shale-beds containing fishes and euripterids, and the underlying red and yellow sandstones. They then proceeded to the higher reaches of the Logan Water to examine the *Ceratiocaris* beds containing the Ludlow fish-band, and further down the stream the overlying *Pterygotus* and *Trochus* beds. A large number of fossils were collected. On returning to Lesmahagow the party were entertained to tea by Mr. Scott M'Kirdy of Birkwood. The distance walked was about 8 miles.

To Glenfalloch, Dumbartonshire, on Saturday, 16th June, Mr. James Anderson, conductor—a joint excursion with the Natural History Society of Glasgow. On arrival by West Highland Railway at Ardlui, the crystalline schists of the district were examined, and the increasing metamorphism towards the north-west was noted. The grits constituting the lower arenaceous zone become more and more broken down and reconstituted, passing from sheared grits along the Highland border into true albite gneisses and mica-schists towards the north-west. Numerous outcrops of altered basic rocks, now epidiorites and hornblende schists, were seen, also a number of later intrusive basalt dykes. The interesting evidences of glaciation of the district were taken note of. The distance walked was about 5 miles.

To the new Mallaig Railway, Inverness-shire, from Friday, 22nd, to Monday, 25th June. On Friday afternoon the party left Queen Street Station, North British Railway, *en route* for Banavie and Corpach. On Saturday morning they started for Mallaig in a saloon carriage supplied by the contractors, Messrs. R. M'Alpine & Sons, and under the guidance of Mr. J. Grant Wilson, of the Geological Survey, saw the more salient features of the district. Leaving Banavie and crossing sandy drift-beds, the line reaches the north side of Loch Eil, and runs along an old sea-beach to the first rock-cutting, through the flagstones of the Central Highland series. Passing the Finnlie Valley it enters on the mica-

Digitized by Google

biotite-gneiss series below the flagstones. Beyond Glen Doilie many interesting sills and dykes of hornblende-schist (supposed to have been once igneous rock, but now folded up amongst the other beds) were carefully examined. In the cutting just before the fine Glen Finnan viaduct of 21 arches, a curious structure of the gneiss, in vertical beds with veins of pegmatite and dykes of hornblende, was seen. Then Loch Shiel was reached, a fresh-water loch about 15 miles long, lying in a deep hollow of the hills, but only 16 feet above sea-level, so that a very slight depression would here bring in the sea. Beyond its head are micaceous rocks alternating with flagstones, and there the summit level of 394 feet was reached, the line here running through a very narrow glen. After a tunnel in curve Loch Eilt was seen to the north lying 300 feet below, and most picturesque with its many small islets (evidently rock-drums) covered with Scotch firs. Beyond Kinloch Ailort came Loch Dubh, a very small "lochan," but so deep that though about 10,000 cubic yards of material had then been emptied into it, the line had not reached the point of safety. Further railway travelling being impracticable, the party walked to the head of Loch na Nuagh and had a glimpse of the Hebridean sea, a fit termination of the trip, though not quite the intended end of the railway. Rejoining the saloon carriage, they returned to their hotel at Corpach, where they spent a pleasant time till the homeward journey on Monday.

To Ben Lomond, Stirlingshire, on Saturday, 30th June, Mr. L. Watt, conductor—a joint excursion with the Edinburgh Field Naturalists' and Microscopical Society, and the Natural History Society of Glasgow. On arrival of the steamer at Rowardennan the ascent of Ben Lomond was made. The schists of which the mountain is formed belong to the lower arenaceous zone, so well seen on the slopes of Ben Ledi, Ben Aan, and Ben Venue, from whence they extend westwards. Along the marginal Highlands the beds of this zone seem to have been packed into a series of isoclinal folds, making them appear much thicker than they really are. A well-marked sub-division of the zone known as "the green beds" (probably overlying the grits) has enabled the Officers of the Survey to understand the character of the structure and folding of this complicated series. The day turned out stormy and wet, which interfered with the success of the excursion. The distance walked was about 8 miles.

To Great Cumbrae, Buteshire, on Saturday, 11th August, Mr. Joseph Sommerville, conductor. On arrival of the party at Keppel Pier by steamer from Fairlie, the Marine Biological Station was visited, and its interesting arrangements for study and research were explained by Mr. Gray, the keeper. The treasures of the late Dr. Robertson's splendid collection of glacial and recent marine remains, now deposited in the Station, were inspected with much interest. Afterwards a walk along the southern shore of the island was taken, and the Old Red Sandstone strata examined, with the numerous intrusive acid and basic dykes, exposed at intervals along the 40-foot terrace and Raised-beach, with the old sea-cliff bordering it. The party returned from Millport by steamer after a walk of about 4 miles.

Digitized by Google

To Fallside and Uddingston, Lanarkshire, on Saturday, 25th August, Mr. William Sinclair, conductor. The red sandstones which overlie the Coal-measures of the Clyde Valley were examined. This group of rocks consists of reddish sandstones, sandy shales, fireclays, and marls, with an occasional thin seam of coal. The altered conditions which had taken place since the deposition of the underlying beds were noted. The walk extended to about 2 miles.

EVENING EXCURSIONS IN 1900.

To the Excavations at the New Power Station at Pinkston and Neighbourhood, on Wednesday, 9th May, Mr. James Anderson, conductor.

To Cuttings on the new Lanarkshire and Ayrshire Railway near Burnside, Rutherglen, on Thursday, 17th May, Mr. James Anderson, conductor.

To a Cutting on the New Renfrew Branch of the Caledonian Railway at Elderslie, on Thursday, 14th June, Mr. William Armour, C.E., conductor. Beds of Fossiliferous Laminated Clay were exposed in this cutting.

Digitized by Google

ABSTRACT OF TREASURER'S ACCOUNTS FOR YEAR ENDING 30TH SEPTEMBER, 1899.

CASH ACCOUNT.

RECEIPTS.								EXPENDITURE.							
Cash in Bank on deposit,	£80	0	0					Printing New Volume and Papers,	£57	17	7				
,, in Treasurer's hands,	4	18	3	£84	18	3		Engraving Illustrations,	2	10	0	£60	7	7
Subscriptions for current year,				66	10	0		New Books,				10	11	6
New Members,				6	0	0		Palæontographical Subscription (two years),	£2	2	0			
Life Member,				5	5	0		Subscription to Millport Marine Station,	1	1	0	3	3	0
Associate Subscriptions,				0	17	6		Rent, Insurance, and Attendance,	£17	5	0			
Publications and Catalogues sold,				4	9	4		Printing Circulars, etc.,	11	14	3			
Interest on Funds,				6	2	7		Lantern Expenses,	3	0	0			
Specimens sold to Corporation of Glasgow,				50	0	0		Collector's Commission,	2	7	6			
								Expenses of Mr. Goodchild's Lecture,	2	2	6			
								Disbursements by Secretaries,	6	10	3			
								,, by Librarian,	2	19	4			
								Postages, Stationery, and Petty Charges,	2	8	1	48	6	11
								Cash in Bank on deposit,	£97	0	0			
								,, in Treasurer's hands,	4	13	8	101	13	8
				£224	2	8						£224	2	8

STOCK ACCOUNT.

To Unpaid Accounts for Printing,				£10	7	6	By Corporation Loan,		£170	0	0			
,, Balance to credit,				761	6	2	,, Cash in Bank and on hand,		101	13	8	£271	13	8
							,, Property—							
							Books,	£440	0	0				
							Furniture, Bookcases, and Microscope,	60	0	0		500	0	0
				£771	13	8						£771	13	8

GLASGOW, 20*th October*, 1899.—Examined and found correct, the balance in the Treasurer's hands being Four pounds thirteen shillings and eightpence.

JOHN R. M'FARLANE, } *Auditors.*
D. PEARSON,

Digitized by Google

ABSTRACT OF TREASURER'S ACCOUNTS FOR YEAR ENDING 30TH SEPTEMBER, 1900.

CASH ACCOUNT.

RECEIPTS.

Cash in Bank on deposit,	£97 0 0		
,, in Treasurer's hands,	4 13 8	£101 13 8	
Subscriptions for current year, and Arrears (£1),		72 0 0	
New Members,		4 0 0	
Associate Subscriptions,		1 0 0	
Publications and Catalogues sold,		2 12 8	
Interest on Funds,		7 16 1	
		£189 2 5	

EXPENDITURE.

Extra copies of Papers,			£0 7 6
New Books,	£3 10 1		
Printing Supplementary Catalogue,	8 0 0		11 10 1
Subscription to Millport Marine Station,			1 1 0
Rent, Insurance, and Attendance,	£13 10 0		
Printing and Postage of Circulars, etc.,	15 9 11		
Lantern Expenses,	0 12 0		
Collector's Commission,	2 5 0		
Disbursements by Hon. Secretary,	1 10 3		
,, by Librarian,	1 13 0		
Postages, Stationery, and Petty Charges,	1 4 9		36 4 11
Cash in Bank on deposit,	£135 0 0		
,, in Treasurer's hands,	4 18 11		*139 18 11
			£189 2 5

*There is a liability against part of this sum for *Transactions* at press.

STOCK ACCOUNT.

To Balance to credit,		£809 18 11	By Campbeltown Corporation Loan, £170 0 0
			,, Cash in Bank and on hand, 139 18 11 — £309 18 11
			,, Property—
			Books, £440 0 0
			Furniture, Bookcases, and Microscope, 60 0 0 — 500 0 0
		£809 18 11	£809 18 11

GLASGOW, 15*th October*, 1900.—Examined and found correct, the balance in Treasurer's hands being Four pounds eighteen shillings and elevenpence.

D. PEARSON,
JOHN R. M'FARLANE, } *Auditors.*

Digitized by Google

THE

GEOLOGICAL SOCIETY OF GLASGOW,

INSTITUTED 1858.

OBJECTS—CONSTITUTION AND LAWS—

MEMBERSHIP—OFFICE-BEARERS.

—

1902.

Digitized by Google

THE GEOLOGICAL SOCIETY OF GLASGOW.

INSTITUTED 1858.

THE objects of the Society are the Advancement of Geological Science by means of Periodical Meetings for its study; the Reading and Discussion of Original Papers on subjects illustrative of Geology and the allied Sciences; the Exhibition and Description of Geological specimens; the Delivery of Lectures; and Excursions to places of Geological interest accessible to Glasgow.

The Meetings are held on the second Thursdays of each month from October to May, and the Excursions are made in the spring, summer, and autumn months, on Saturday afternoons, or on public holidays.

There is a large Library of Books on Geological and kindred subjects, which is added to from time to time. The books can be borrowed by members for home reading.

The *Transactions* of the Society are published annually, and all Life and Ordinary Members on the roll, who are not in arrears of their subscription, are entitled to receive a copy of each part issued during their term of membership.

The Life Membership subscription is one payment of Five Guineas, and that for Ordinary Membership 10s. per annum, payable on election, and thereafter on 1st October. There is no Entry-money. Associate Membership for students and others attending Geological classes may be had at a subscription of 2s. 6d. per annum.

JAMES BARCLAY MURDOCH, *Hon. Secretary*,
Capelrig, Newton-Mearns, Renfrewshire.

PETER MACNAIR, *Assist. Hon. Secretary*,
Art Galleries and Museum, Kelvinside, Glasgow.

Digitized by Google

THE GEOLOGICAL SOCIETY OF GLASGOW.

INSTITUTED 1858.

CONSTITUTION AND LAWS,

AS AMENDED, SESSION 1874-75.

I.—NAME.

The Society shall be called "THE GEOLOGICAL SOCIETY OF GLASGOW."

II.—OBJECTS.

The objects of the Society shall be—

I. To unite, in permanent working association, the students and friends of Geological Science residing in Glasgow and surrounding districts.

II. The advancement of that science, by means of periodical Meetings for its study; the reading and discussion of original Papers on subjects illustrative of Geology or its allied Sciences; the exhibition and description of specimens; the delivery of Lectures during winter; and by Excursions in summer.

III. The formation of a Library and a Museum, specially to illustrate the Geologyand Palæontology of the district.

IV. The publication of the Society's *Transactions.*

III.—CONSTITUTION.

The Society shall consist of—I. Ordinary and Life Members; II. Honorary Members; III. Honorary Associates; IV. Corresponding Members.

IV.—ORDINARY AND LIFE MEMBERS.

All candidates for Membership shall be proposed on the recommendation of two Members, at one Meeting, and their

Digitized by Google

election put to the vote from the Chair at the following Meeting, whether Ordinary or Special, provided that their names shall be announced in the Circular calling the Meeting at which they are to be brought forward for election. If not unanimous, the vote shall be taken by ballot, and a majority shall suffice for election.

The Annual Subscription shall be—for Gentlemen, 10s., and for Ladies, 7s. 6d., payable upon election, and thereafter at the first Ordinary Meeting of each Session in October.

Members whose Subscriptions are in arrear shall not be entitled to vote, nor to use the Library, nor to receive the printed *Transactions* of the Society.

Members shall be held liable for their Annual Subscriptions until they have given the Secretary written notice of their resignation.

A single payment of Five Guineas shall entitle any Member elected as aforesaid to be entered as a Life Member of the Society.

V.—HONORARY MEMBERS, HONORARY ASSOCIATES, AND CORRESPONDING MEMBERS.

The Ordinary Members shall have power to elect—on the motion of two of their number—Honorary Members, Honorary Associates, and Corresponding Members, at any Meeting, provided notice of said motion has been tabled at a previous Meeting and received the sanction of a majority of the whole Council. The votes of two-thirds of the Members present shall be requisite for the election of all such Members.

(1.) Persons distinguished for their attainments in Geology or the allied Sciences shall be eligible as *Honorary Members*. These shall be entitled to the same privileges as Ordinary and Life Members.

(2.) Persons resident in Glasgow or neighbourhood, who may have benefited the Society by services rendered, by donations of books or specimens, or by the contribution of original communications, shall be eligible as *Honorary Associates*.

(3.) Friends and Students of Geological Science resident at a distance, who may be willing to forward information or communications to the Society, shall be eligible as *Corresponding Members*.

Digitized by Google

Honorary Associates and Corresponding Members shall be entitled to attend the Meetings, Lectures, and Excursions of the Society, but shall have no vote in the management of its affairs, nor be entitled to receive copies of the *Transactions*, except at the discretion of the Council.

VI.—OFFICE-BEARERS.

The business of the Society shall be conducted by a Council of twenty, consisting of a President, three Vice-Presidents, a Corresponding Secretary, a Joint Secretary, a Treasurer, and a Librarian (who shall also be Curator of the Museum), and twelve Councillors, to be elected as hereinafter prescribed.

Mode of Election.

The election of Office-Bearers shall take place by ballot, at the Annual General Meeting of the Society. The names of those intended to be proposed as Office-Bearers, together with their proposers and seconders, shall be sent in to the Secretary at least eight days before the Annual General Meeting, and submitted to a meeting of Council, and intimated in the Circular calling the Annual General Meeting.

Term of Office, &c.

The President shall be elected for three years, and shall be eligible for re-election. He shall be Chairman of the Council, and of all Meetings at which he may be present. In his absence, one of the Vice-Presidents, or, failing them, a Member of the Council shall preside.

One of the Vice-Presidents and four of the Council shall retire annually by rotation, to be arranged in the first instance after these Rules are passed, by those having the lowest number of votes at election retiring from office at the end of the first year, and the next lowest at the end of the second year; after which they shall retire in regular rotation by seniority of office.

In the event of an equality of votes, a second ballot shall be taken.

The retiring Vice-President and Members of Council shall not be eligible for re-election to the offices from which they retire until they have been one year out of said offices.

Digitized by Google

The Secretaries, Treasurer, and Librarian shall be eligible for re-election.

VII.—SECRETARIES.

The Corresponding Secretary shall conduct the correspondence, and record in the Minute-Book the proceedings of all Meetings of the Society, the Council, and Sub-Committees, of which he shall be *ex-officio* a Member.

The Minutes of all such Meetings respectively shall be read and confirmed as the first business of the next ensuing Meeting.

The Corresponding Secretary shall also edit the *Transactions* of the Society, and superintend the publication of same as often as may be approved of by the Council. A *Publishing Committee*, consisting of two or three Members, to be elected annually by the Council, shall be associated with the Secretary for this purpose, as also to assist in preparing Abstracts of Papers, Reports of Excursions, &c.

The Joint Secretary shall take the charge of calling all Meetings of the Society or Council, and sending out all Circulars to the Members regarding Lectures, Excursions, &c. For this purpose he shall keep a Register of the names of Members of the Society, for reference.

He shall also take the place of the Corresponding Secretary at all Meetings, when the latter may be absent.

VIII.—TREASURER.

The Treasurer shall receive and pay (as authorised by the Council, or by any General or Special Meeting of the Members) all moneys connected with the Society, and shall keep a regular account of the same, which account shall be balanced as on the 30th of September of each year, audited by two Members other than Members of Council, appointed at an Ordinary Meeting, and submitted to the Annual Meeting in October.

IX.—LIBRARIAN AND CURATOR.

The Librarian shall have charge of the Society's Library, and shall arrange and keep a Catalogue thereof. He shall also have charge of the Museum, and of all Property belonging to the Society.

Digitized by Google

The *Transactions* shall be exchanged with such Societies and Geological Authors at home and abroad as may be approved of by the Council. The Librarian shall have charge of such exchanges, and shall keep a correct list thereof, for purposes of reference.

X.—COUNCIL.

The Council shall meet as often as may be requisite for the transaction of business—five shall form a quorum. They may appoint Sub-Committees for the management of special business, and shall issue yearly, prior to the Annual Meeting, a Syllabus of their arrangements for the Winter Session; and before its close, one of their arrangements for the Summer Excursions.

Any vacancy occurring in the Council during the year may be filled up by the Council; but such elections to fill vacancies shall only be for the unexpired portion of the previous occupants' term of office. Members so elected, however, shall be eligible for re-election if their period of office has not extended to two years.

XI.—MEETINGS.

Ordinary Meetings of the Society shall be held once a month during the Session, on the first or second Thursday evening of each month, at eight o'clock; but more frequently if the Council should deem it advisable. At these Meetings, after the Minutes of the previous Meeting have been read and confirmed, the vote shall be taken on Members who have been proposed; other new Members may then be proposed; Papers read and discussed; Specimens exhibited and remarked upon, and any other business disposed of.

The Session shall last from October to April. The first Meeting of each Session shall be an Ordinary Meeting. The second Meeting, at such interval from the first as may be fixed upon, shall be the

Annual General Meeting,

At which one of the Secretaries shall give a report of the proceedings of the Society during the past year; the Treasurer shall submit a Statement of the Cash Account, audited by the two Members appointed for that purpose; and the Librarian and Curator shall report on the progress and condition of the

Digitized by Google

Library and Museum. The election of Office-Bearers shall then be proceeded with.

Special Meetings.

The Council or Secretary shall be empowered to call, at any time when necessary, a Special Meeting of the Society, and shall be bound to do so, on the written requisition of ten Members, specifying the business to be submitted thereto.

At all Meetings, the resolutions of a majority of those present—with the exception stated in Laws V. and XV.—shall be binding. The Chairman shall have both a deliberative and a casting vote.

All Meetings shall be intimated to the Ordinary and Life Members by Circular.

XII.—LIBRARY AND MUSEUM.

The Members shall have access to the Library and Museum on the nights of meeting, and at such other times as the Council may direct.

The Rules approved of by the Council for the conduct of the Library shall be printed along with the Catalogue.

XIII.—VESTING OF PROPERTY.

The property of the Society shall belong solely to the Ordinary and Life Members, and shall be vested for their behoof in the Council for the time being. The Council shall have the management of the property, and power to sell or otherwise dispose of any duplicate Books or Specimens; any other property which they may consider unnecessary to retain shall only be disposed of with the consent of a majority of the Ordinary and Life Members present at a Meeting of the Society. Notice shall be given in the Circular calling the Meeting of the intention to ask such consent.

XIV.—APPLICATION OF FUNDS.

The Annual Subscriptions shall be chiefly devoted to the Publication of the Society's *Transactions*, of which each Member shall be entitled to receive a copy, beginning with the Part relating to the Session in which he has been elected.

Should the Subscriptions at any time be insufficient for this purpose, the Council shall have power to fix such a charge for

Digitized by Google

each Part of the *Transactions* as may be required to make up the deficiency.

Duplicates and back Parts shall in all cases be charged for at full publishing price.

Authors of Papers printed in the *Transactions* shall be entitled to receive thirty copies of their papers free.

Sums may be voted from time to time by the Council to the Library and Museum, out of any funds there may be on hand. No purchase of Books or Specimens exceeding Two Pounds in value shall be made without the sanction of a General Meeting of the Society.

The Subscriptions of Life-Members shall be retained as a separate Fund for the re-publication of such *Memoirs* or Parts of the *Transactions* as may be out of print, and be still in demand; for the expense of special Publications or of Exhibitions in connection with the visits of learned Societies; and generally for such exceptional purposes as are not provided for by the Annual Subscriptions.

The Council shall obtain the sanction of the Society at a General Meeting before applying any portion of this Fund.

XV.—ALTERATION OF CONSTITUTION OR LAWS.

No alteration shall be made in the Constitution or Laws of the Society except at a General Meeting specially intimated for that purpose. Notice of any proposed alteration shall be tabled at the Ordinary Meeting preceding, and shall not be adopted unless agreed to by two-thirds of the Members present.

XVI.

Any Contingency not provided for in these Rules shall be submitted to the Council, and their decision shall be final and binding on all concerned.

Digitized by Google

THE
GEOLOGICAL SOCIETY OF GLASGOW.

Office-Bearers for Session 1901-1902.

President—

Prof. CHARLES LAPWORTH, LL.D., F.R.S., F.G.S.,
Professor of Geology and Physiography in the University of Birmingham.

Vice-Presidents—

For Three Years.	*For Two Years.*	*For One Year.*
James Stark.	R. Kidston, F.G.S.	Matthew Blair.

Members of Council—

Bailie Wm. Maclay, F.G.S.	John Renwick.	W. Armour, C.E.
James Neilson (1).	James Steel.	Jos. Sommerville.
James Neilson (2).	William Sinclair.	John Orr.
David Chalmers.	David Nimmo.	Charles R. Cowie.

Auditors—

James Anderson. | David Pearson.

Honorary Secretary—

James Barclay Murdoch, F.R.Ph.S.E., Capelrig, Newton-Mearns.

Assistant Honorary Secretary—

Peter Macnair, Art Galleries and Museum, Kelvingrove, Glasgow.

Honorary Treasurer—

E. Hall Wight, C.A., 150 Hope Street.

Honorary Librarian—

J. S. M'Lennan, Oswald School, Jordanhill.

COMMITTEES APPOINTED BY THE COUNCIL.

Printing and Publishing Committee—

James Neilson (1).	John Renwick.	Peter Macnair.
William Armour.	J. S. M'Lennan.	J. B. Murdoch, *Con.*

Library Committee—

John Renwick.	Peter Macnair.	Wm. Armour, *Jt.-Con.*
Jos. Sommerville.	James Neilson (2).	J. S. M'Lennan, *Jt.-Con.*

Excursions Committee—

Wm. Armour.	David Chalmers.	Peter Macnair.
Jos. Sommerville.	David Nimmo.	John Renwick, *Con.*
James Steel.		

Finance Committee—

Matthew Blair.	James Neilson (2)
James Stark.	E. H. Wight, *Con.*

Photographic Committee—

David Nimmo.	Charles R. Cowie.	Wm. Sinclair, *Con.*
A. Laird.	S. Fingland.	

Digitized by Google

THE GEOLOGICAL SOCIETY OF GLASGOW.

(INSTITUTED 1858.)

LIST OF MEMBERS, 31st MAY, 1902.

Honorary Members.

Year of Election.

1865. Geikie, Sir Archibald, D.C.L., LL.D., F.R.S., F.G.S., F.Z.S., 10 Chester Terrace, Regent's Park, London, N.W.

1867. Jones, T. Rupert, F.R.S., F.G.S., 17 Parson's Green, Fulham, London, S.W.

1867. Woodward, Henry, LL.D., F.R.S., F.G.S., F.Z.S., F.R.M.S., 129 Beaufort Street, Chelsea, London, S.W.

1867. M'Chesney, Joseph H., Professor of Geology, University of Chicago, U.S.A.

1871. Hull, Edward, M.A., LL.D., F.R.S., F.G.S., 20 Arundel Gardens, Notting Hill, London, W.

1872. Kelvin, Right Hon. Lord, G.C.V.O., D.C.L., LL.D., F.R.S., Netherhall, Largs, Ayrshire.

1872. Young, John, M.D., ex-Professor of Natural History, University of Glasgow, 38 Cecil Street, Hillhead, Glasgow.

1883. Judd, J. W., C.B., LL.D., F.R.S., F.G.S., Professor of Geology in the Royal College of Science, London, 22 Cumberland Road, Kew, London.

1888. Murray, Sir John, K.C.B., LL.D., F.R.S., F.L.S., F.R.G.S., *P*.R.S.G.S., Challenger Lodge, Wardie, Edinburgh.

1900. Gray, Mrs. Robert, 59 George Street, Edinburgh.

Honorary Associates.

1867. Struthers, Thomas, Gourock. [1859] *

1871. Horne, James, 71 Carlton Hill, St. John's Wood, London. [1858]

* The date *after* a name is that of previous election as an Ordinary Member.

Digitized by Google

Year of Election.

1871. Farie, James, Canonbury, London. [1859]

1878. Lapworth, Charles, LL.D., F.R.S., F.G.S., Professor of Geology and Physiography in the University of Birmingham, 28 Duchess Road, Edgbaston, Birmingham. *President.*

1883. Traquair, R. H., M.D., LL.D., F.R.S., F.G.S., Museum of Science and Art, Edinburgh.

1883. Geikie, James, LL.D., D.C.L., F.R.S., F.G.S., F.R.G.S., Professor of Geology and Mineralogy in the University of Edinburgh, Kilmorie, Colinton Road, Edinburgh. [1873]

Corresponding Members.

1859. Dougall, John, M.D., 493 Shields Road, Pollokshields, Glasgow.

1860. Sommerville, George, Thornliebank.

1864. Mitchell, Rev. Hugh, LL.D., Craig, Montrose.

1865. Winchell, Alex., Professor of Geology, University of Michigan, U.S.A.

1866. Gloag, Rev. Dr. Paton J., 28 Regent Terrace, Edinburgh.

1867. Kerr, David, Wemyss Colliery, Fifeshire.

1871. Jack, R. L., LL.D., F.G.S., 36 Overstrand Mansions, Battersea Park, London, S.W.

1871. Jamieson, T. F., F.G.S., Ellon, Aberdeenshire.

1871. Kinahan, G. H., late Geological Survey of Ireland, Dublin.

1871. Ward, John, F.G.S., 23 Stafford Street, Longton, Staffordshire.

1883. Scott, Thomas, F.L.S., Menzies Road, Torry, Aberdeen. [1880]

1883. Smith, W. Anderson, late of Ledaig.

1884. Dobbie, J. J., M.A., D.Sc., Professor of Chemistry, University College, Bangor, North Wales. [1876]

1884. Nathorst, Professor Alfred Gabriel, Stockholm, Sweden.

1898. Livingston, Colin, Ardtraigh, Fort-William.

Ordinary and Life Members.

1882. Anderson, James, 55 Gibson Street, Glasgow.

1902. Andrews, H.W., Hope Street, Glasgow.

1881. Armour, William, C.E., 207 West George Street, Glasgow.

Digitized by Google

Year of Election.

1898. Bain, James, Whins House, Alloa.
1900. Bannerman, William, 28 Glencairn Drive, Pollokshields, Glasgow.
1894.*Barlas, George, 15 Ruthven Street, Kelvinside, Glasgow.
1894.*Barr, Prof. Archibald, Royston, Dowanhill, Glasgow.
1894.*Barr, James, M.I.C.E., F.S.I., 221 West George Street, Glasgow.
1893. Barr, Patrick, 51 Bath Street, Glasgow.
1881.*Barr, Thomas M., C.E., Caledonian Railway, Perth. [1858]
1901. Barron, Archd. Campbell, Woodbank House, Dailly, Ayrshire.
1902. Blackwood, Matthew, Ardmore, Port Glasgow.
1889. Blair, Matthew, The Moorings, Thornly Park, Paisley. *Vice-President.*
1900. Begg, Thomas, Elms, Mount Vernon.
1899. Borland, Matthew, 150 Westmuir Street, Parkhead, Glasgow.
1887. Boyd, John, Mount Blow, Maxwell Drive, Pollokshields, Glasgow.
1895. Brown, Rev. Alexander, 4 Leslie Road, Pollokshields, Glasgow.
1887. Brown, Andrew, Bruce Villa, North Mount Vernon.
1892. Brown, John A., Dowanhill Gardens, Dowanhill, Glasgow.
1894.*Bryden, Robert A., 212 St. Vincent Street, Glasgow.
1877. Buchanan, John, 233 Duke Street, Glasgow.
1898. Burdon, Andrew M., M.A., 30 Kyle Park, Uddingston.
1894. Burnett, John James, A.R.S.A., 18 University Avenue, Hillhead, Glasgow.

1902. Cairncross, John M., M.E., 2 Murray Place, Weir Street, Coatbridge.
1901. Callander, J. Graham, F.S.A. Scot., 20 Rupert Street, Glasgow.
1901. Campbell, John F., 15 Montgomerie Street, North Kelvinside, Glasgow.
1877. Campbell, John M'Naught, 5 Franklin Terrace, Glasgow.
1898. Campbell, John R., 15 St. Vincent Place, Glasgow.
1880. Carmichael, Robert S., Audit Office, St. Enoch Station, Glasgow.
1895.*Cassells, John, 154 Queen's Drive, Crosshill, Glasgow.
1900. Cathcart, George M., 2 Colebrooke Street, Hillhead, Glasgow.
1895. Chalmers, David, 16 Berkeley Terrace, Glasgow.
1875.*Clavering, Thomas, 27 St. Vincent Place, Glasgow.
1891. Cowie, Charles R., Woodend, Partick.

* The names of Life Members have an asterisk (*) prefixed. If they were Ordinary Members previously, the date of the original election is placed *after* the name, in brackets ([ ]).

Digitized by Google

Year of Election.

1900.*Cozens, Samuel F., Salem, Skelmorlie.
1899. Cree, James Paterson, 18 Bengal Place, Pollokshaws East.

1877.*Dansken, John, 241 West George Street, Glasgow.
1902. Dewar, John, 132 Main Street, Glasgow.
1898. Dick, Robert, Castlewood, Cathcart.
1894. Dixon, Walter, 59 Bath Street, Glasgow.
1883.*Dobbie, C. Lizars, 21 St James' Street, Hillhead, Glasgow.
1897. Donaldson, Archibald, 143 Abercromby Street, Glasgow.
1881.*Dougan, John, 69 Cadder Street, Pollokshields, Glasgow.
1889. Douglas, William, Golconda, Kilwinning.
1895. Dron, R. W., A. M. Inst. C. E., 55 West Regent Street, Glasgow.
1888. Dow, Walter, Bekeni, Dalziel Drive, Pollokshields, Glasgow.
1887. Dow, William, 16 Abbotsford Place, Glasgow.
1901. Du Toit, Alexander L., 26 Newton Street, Glasgow.
1883. Dunlop, Robert, Orepuki, Southland, New Zealand.

1901. Faill, John, 7 Winton Drive, Kelvinside, Glasgow.
1900. Farrell, Richard C., C.E., 10 Wellington Street, Glasgow.
1898. Fergus, A. Freeland, M.D., 22 Blythswood Square, Glasgow.
1898. Fergus, Mrs. Oswald, 12 Claremont Gardens, Glasgow.
1899. Ferguson, William Pettigrew, 166 Buchanan Street, Glasgow.
1897. Fingland, Samuel, Braehead Villa, Cathcart.
1895. Fingland, Mrs., Braehead Villa, Cathcart.
1901. Finlayson, Malcolm J., B.A., Headmaster, Burgh School, Girvan.
1895. Forbes, Alexander, Lecturer on Mining, St. Leonards Road, Ayr.
1900. Forgie, James T., M.I.M.E., Viewfield, Bothwell.
1901. Forsyth, William, 6 Windsor Terrace, Glasgow.
1898.*French, Thomas, 1 Kelvinside Terrace, Kelvinside, Glasgow.

1866. Gale, James M., C.E., Corporation Water Works, Glasgow.
1901. Gale, William M., C.E., Corporation Water Works, 18 Huntly Gardens, Kelvinside, Glasgow.
1892. Galloway, T. Lindsay, C.E., 31 Mair Street, Glasgow.
1887. Gardner, John, 19 Commerce Street, Glasgow.
1901. Gemmell, E. W., 1 Valeview Terrace, Langside, Glasgow.
1893. Gemmell, Matthew, 160 Bath Street, Glasgow.
1897. Gilfillan, Thomas, Stirling Drive, Blairbeth Road, Rutherglen.
1894.*Gilfillan, William, 129 St. Vincent Street, Glasgow.

Digitized by Google

Year of Election.

1884. Gill, Robert, 63 West Regent Street, Glasgow.
1878.*Gilmour, Thomas, M.D., Port Ellen, Islay. [1873]
1895. Glen, Alexander, 25 Dumbreck Road, Glasgow.
1894. Goldie, James, 52 St. Enoch Square, Glasgow.
1900.*Graham, M. M., 21 Bath Street, Glasgow. [1877]
1866. Grant, James, 8 Queen's Terrace, Glasgow.
1886. Guy, Robert, 120 West Regent Street, Glasgow.

1872. Hamilton, Archibald, C.E., Clyde Navigation Office, Robertson Street, Glasgow.
1876. Henderson, John, Ravenscraig, Dumbreck, Glasgow.
1877. Hill, Thomas N., 180 Hope Street, Glasgow.
1877. Hislop, G. R., F.C.S., F.R.S.S.E., Corporation Gas Works, Paisley.
1891. Hodge, William, 27 Montgomerie Drive, Kelvinside, Glasgow.
1897. Houston, Robert S., Eversdale, Hawkhead Road, Paisley.
1901. Howie, George, Clydeside Cottage, Uddingston.
1894. Hubbard, John James, 9 Bute Gardens, Hillhead, Glasgow.
1894. Hubbard, Walter Raglan, 9 Broomhill Avenue, Partick.
1866. Hunt, Edmund, C.E., 121 West George Street, Glasgow.
1901. Hunter, James, Townhead Public School, Kirkintilloch.
1901. Hunter, William, Rosemount, Ledard Road, Langside, Glasgow.

1893. Innes, Peter, 5 Ibrox Place, Paisley Road West, Glasgow.

1902. Jackson, Daniel, Thornbank, Dumbarton.
1897. Jeffrey, William, c/o Copeland, 56 College Street, Glasgow.
1890. Johnstone, Ronald H., C.E., 238 West George Street, Glasgow.
1884. Jolly, William, F.R.S.E., F.G.S., Blantyre Lodge, Blantyre.

1901. Kemp, William, 1 Doune Quadrant, Kelvinside, Glasgow.
1870.*Ker, William, 1 High Windsor Terrace, Glasgow.
1890. Kidston, Robert, F.G.S., 12 Clarendon Place, Stirling. *Vice-President.*
1877. Kincaid, Thomas, 9 Lansdowne Crescent, Glasgow.
1882. King, Hugh B., Kilwinning, Ayrshire.
1899. King, Peter, Darngavil, Airdrie.
1882. King, Robert C., C.A., Kilwinning, Ayrshire.
1894. Knight, Rev. G. A. Frank, M.A., U. F. Manse, Auchterarder.

Digitized by Google

Year of Election.

1883. Laird, Andrew, C.E., 190 West George Street, Glasgow.
1892. Laird, Alexander, Cairleon, Kilmalcolm.
1901. Leighton, William, 120 Hope Street, Glasgow.
1899. Lockhart, W. M., 151 Sword Street, Dennistoun, Glasgow.
1901. Lothian, A. Veitch, M.A., B.Sc., F.R.S.E., 11 Holborn Terrace, Glasgow.
1880. Lucas, William, 140 Hope Street, Glasgow.
1899. Lyle, William, 7 Beechwood Terrace, Shettleston, Glasgow.

1894. M'Ara, Alexander, 19 Dundonald Road, Glasgow.
1866. M'Clelland, Andrew S., C.A., 115 St. Vincent Street, Glasgow.
1895. M'Connell, Alexander, C.E., c/o John Paterson & Sons, Ltd., 610 Pollokshaws Road, Glasgow.
1896. M'Cowan, Donald, Dundashill House, Port-Dundas, Glasgow.
1889. M'Creath, George W., M.E., 208 St. Vincent Street, Glasgow.
1901. M'Culloch, Andrew, 11 West Regent Street, Glasgow.
1901. MacCulloch, Rev. J. D., Congregational Manse, Galston.
1884. M'Donald, A. B., C.E., 64 Cochrane Street, Glasgow.
1898. M'Gavin, Alex., 23 Melrose Gardens, North Kelvinside, Glasgow.
1894.*M'Gilvray, Robert A., 129 West Regent Street, Glasgow.
1867. M'Glashan, John, 114 Candleriggs, Glasgow.
1882. Macintosh, Rev. John, B.D., The Manse, Uddingston.
1898. M'Intyre, J. H., 2 Victoria Gardens, Dowanhill, Glasgow.
1898. M'Kellar, John, 25 Kelvinside Terrace, South Kelvinside, Glasgow.
1894. Mackie, John, M.E., Millview, Neilston.
1901. Mackirdy, W. A. Scott, Birkwood, Lesmahagow.
1886. M'Laren, Robert, Bonny Gardenside, Uddingston.
1894. Maclay, James, 3 Woodlands Terrace, Glasgow.
1877. Maclay, Bailie William, F.G.S., Thornwood, Langside, Glasgow.
1882. M'Lennan, J. S., Oswald Public School, Knightswood, Maryhill. *Honorary Librarian.*
1895. Macnair, Peter, Art Galleries and Museum, Kelvingrove, Glasgow. *Assist. Honorary Secretary.*
1897.*M'Neil, Charles, South Cliff, Wemyss Bay.
1883. M'Whirr, John, 2 St. John's Road, Cathcart.
1887. Main, John, F.G.S., 14 Clydeview, Partick.
1900. Mann, Andrew C., 30 Lansdowne Crescent West, Kelvinside, Glasgow.
1874. Marshall, Robert, 97 Wellington Street, Glasgow.

Digitized by Google

Year of Election.

1901. Marshall, Robert, Headmaster Parish School, Friedensheim, Girvan.
1899. Martin, John Allan, 1246 Dumbarton Road, Whiteinch.
1900. Martin, William, 4 North Court, Royal Exchange, Glasgow.
1881. Mitchell, G. A., 5 West Regent Street, Glasgow.
1899. Mitchell, J. M., Banker, Auchengray, Airdrie.
1900. Moffat, James, 35 Gardner Street, Partick.
1877. Moore, Robert T., B.Sc., C.E., 156 St. Vincent Street, Glasgow.
1885. More, Robert, 505 Sauchiehall Street, Glasgow.
1900. Morton, William, Cairntable, Newlands, Glasgow.
1889. Motherwell, A. B., British Linen Company Bank, Airdrie.
1900.*Muirhead, John, 13 St. John's Drive, Pollokshields, Glasgow.
1898. Munro, Alexander, 1 Colebrooke Place, Hillhead, Glasgow.
1859. Murdoch, J. Barclay, F.R.Ph.S.E., Capelrig, Newton-Mearns, Renfrewshire. *Honorary Secretary.*
1894.*Murdoch, Robert, 91 Maxwell Road, Glasgow.
1870. (1.) *Murray, David, LL.D., 169 West George Street, Glasgow.
1898. (2.) Murray, David, M.A., B.Sc., 5 Howard Park Drive, Kilmarnock.

1891. (1.) Neilson, James, Milnbank House, Dennistoun, Glasgow.
1894. (2.) *Neilson, James, 116 Bishop Street, Port-Dundas, Glasgow.
1898. Nimmo, David, 17 Duke Street, Hamilton.
1894. Niven, Thomas Ogilvie, 131 West Regent Street, Glasgow.

1897.*Orr, John, 12 Newhall Terrace, Glasgow. [1869]

1875. Pearson, David, 9 Roxburgh Street, Glasgow.
1901. Petrie, William, 6 Willowbank Crescent, Glasgow.
1891. Pollock, Arthur, Kirkland, Bonhill, Dumbartonshire.
1899. Purvis, William, 66 St. Vincent Crescent, Glasgow.

1873. Rankine, David, C.E., 238 West George Street, Glasgow.
1880. Reid, James A., M'Grigor, Donald & Co., 172 St. Vincent Street, Glasgow.
1901. Reid, William, 2 Firpark Terrace, Glasgow.
1874. Renwick, John, 49 Jamaica Street, Glasgow.
1901. Richards, Thomas J., 11 Wilton Mansions, North Kelvinside, Glasgow.

Digitized by Google

Year of Election.

1900. Robertson, G. W. T., 120 Bath Street, Glasgow.
1875.*Rottenburg, Paul, Holmhurst, Dowanhill Gardens, Glasgow.

1898. Scott, John, 300 Caledonian Road, Wishaw.
1893. Sexton, Prof. A. Humboldt, Technical College, 204 George Street, Glasgow.
1897. Shanks, Archibald, Mount Pleasant, Dalry, Ayrshire.
1891.*Sharp, John Grant, 127 Great Hamilton Street, Glasgow.
1889. Simpson, Rev. Alexander, B.A., B.Sc., F.G.S., 28 Myrtle Park, Crosshill, Glasgow.
1899. Sinclair, Alexander T., Howard Villa, Maryhill.
1888. Sinclair, Thomas, 206 New Dalmarnock Road, Glasgow.
1887. Sinclair, William, 45 Oswald Street, Glasgow.
1889. Sloan, Samuel, M.D., 5 Somerset Place, Sauchiehall Street, Glasgow.
1891. Smith, James Parker, M.P., Jordanhill, Partick.
1865. Smith, John, Monkredding, Kilwinning, Ayrshire.
1901. Sneddon, Richard, 73 Pitt Street, Newton, Cambuslang.
1871. Sommerville, Joseph, 40 Montgomerie Street, North Kelvinside, Glasgow.
1887. Sommerville, Rev. James E., B.D., Castellar, Crieff.
1899. Sommerville, William, Carronben, Buchanan Drive, Cambuslang.
1900. Sorley, Bailie Robert, The Firs, Partickhill, Glasgow.
1902. Spencer, James, jun., 2 Kelvingrove Terrace, Glasgow.
1896. Stark, James, 13 Princes Gardens, Partick. *Vice-President.*
1881. Steel, James, 391 St. George's Road, Glasgow.
1884. Steele, Robert Innes, 3 Nithsdale Place, Pollokshields, Glasgow.
1901. Stewart, Andrew, Lairdsland School, Kirkintilloch.
1878. Stewart, Thomas, Hydraulic Engineers' Depôt, Cape Town, South Africa.
1898. Stewart, W. S., F.R.A.S., Levern, Barrhead.
1891. Stirling, David, 370 Eglinton Street, Glasgow.

1896. Thompson, Prof. G. R., Yorkshire College, Leeds.
1897. Thomson, Henry, 10 Princes Square, Strathbungo, Glasgow.
1894. Thomson, William Brown, Banker, Wishaw.
1885. Tullis, David, Glencairn, Burnside, Rutherglen.
1885. Tullis, James T., Aytoun House, Sydenham Road, Dowanhill, Glasgow.

Digitized by Google

Year of Election.

1901. Wallace, John, 21 Moir Street, Glasgow.
1902. Watson, Henry, 8 Victoria Crescent, Dowanhill, Glasgow.
1874. Whyte, John, Hollybank, Stirling.
1880. Whitelaw, Thomas, 112 Wellington Street, Glasgow.
1901. Wight, Edward Hall, C.A., 150 Hope Street, Glasgow.
Honorary Treasurer.
1866. Wight, John, C.A., 150 Hope Street, Glasgow.
1881. Wotherspoon, David, 130 Dumbarton Road, Glasgow.

1896.*Young, James, junr., Carlacon, Bearsden.
1899. Young, Robert S., 56 Mitchell Street, Glasgow.

Digitized by Google

PUBLICATIONS OF THE SOCIETY.

TRANSACTIONS.—Demy 8vo.

Vol. I., Part 1.—The Geology of the Campsie District. By John Young, LL.D., F.G.S. (3rd edition, revised), 2/
——— Part 2.—The Phenomena of the Glacial Drift of Scotland. By Sir Archibald Geikie, F.R.S. (*Reprint*), - 5/
Vol. II., Part 1.—Papers on Local and Theoretical Geology, - - 4/6
——— Part 2.— Do. do. do., (*Out of Print*).
——— Part 3.— Do. do. do., - - - 4/6
Vol. III., Part 1.— Do. [contains "On Geological Time." By Lord Kelvin, F.R.S.], - - - 4/
——— Part 2.— Do. [contains "On Geological Dynamics." By Lord Kelvin, F.R.S.], - - 4/
——— (Supplement)—On the Carboniferous Fossils of the West of Scotland. By John Young, LL.D., F.G.S., and James Armstrong, - - (*Out of Print*).
Vol. IV., Part 1.—Papers on Local and Theoretical Geology, - - 3/
——— Part 2.— Do. do. do., - - 3/
——— Part 3.— Do. do. do., - - 3/
Vol. V., Part 1.— Do. do. do., - - 4/
——— Part 2.— Do. [contains "Geological Climate." By Lord Kelvin, F.R.S.], - - - 4/
Vol. VI., Part 1.— Do. [contains "The Internal Condition of the Earth." By Lord Kelvin, F.R.S.], 4/
——— Part 2.—Papers on Local and Theoretical Geology, - 4/
Vol. VII., Part 1.— Do. do. do., - 5/
——— Part 2.— Do. do. do., - 5/
Vol. VIII. Part 1.— Do. do. do., - 5/
——— Part 2.— Do. [contains "Polar Ice Caps and their Influence in changing Sea Levels." By Lord Kelvin, F.R.S.], - - - - 5/
Vol. IX. Part 1.—Papers on Local and Theoretical Geology, - 6/6
——— Part 2.— Do. do. do. - 6/6
Vol. X. Part 1.— Do. do. do. - 6/6
——— Part 2.— Do. do. do. - 7/
Vol. XI. Part 1.— Do. do. do. - 6/
——— Part 2.— Do. do. do. - 7/
——— (Supplement)—Drift or Glacial Deposits of Ayrshire. By John Smith, - - - - - - 4/
Vol. XII. Part 1.—Papers on Local and Theoretical Geology, - - 5/
——— Part 2.—In Preparation.

PALÆONTOLOGICAL SERIES.—Demy 4to.

Part 1.—Containing Four Plates with many Figures, - - - 3/6

CATALOGUE OF WESTERN SCOTTISH FOSSILS.

Compiled for the Meeting of the British Association, Glasgow, 1876. Crown 8vo, cloth, - - - - - - - - - - - 2/6
The same, interleaved for Notes, and bound in Leather, - - - 3/6

THE GEOLOGY OF THE CLYDE DRAINAGE AREA.

Compiled for the Meeting of the British Association, Glasgow, 1901. Demy 8vo, cloth, - - - - - - - - - - - 3/

THE GEOLOGY OF THE CAMPSIE DISTRICT.

By John Young, LL.D., F.G.S. Third edition, 1894. Demy 8vo, - 2/

THE PHENOMENA OF THE GLACIAL DRIFT.

By Sir Archibald Geikie, F.R.S. (*Reprint.*) Demy 8vo, - - - 5/

THE DRIFT OR GLACIAL DEPOSITS OF AYRSHIRE.

By John Smith. Demy 8vo, - - - - - - - - - 4/

Copies of the above may be had from the Hon. Librarian, Mr. JAMES S. M'LENNAN, at the Society's Rooms, 207 Bath Street, Glasgow; *or by order through any Bookseller.*

Digitized by Google

Digitized by Google

THE NEW YORK
PUBLIC LIBRARY
ASTOR, LENOX AND
TILDEN FOUNDATIONS

Digitized by Google

Digitized by Google

PUBLICATIONS OF THE SOCIETY.

TRANSACTIONS.—Demy 8vo.

Vol. I., Part 1.—The Geology of the Campsie District. By John Young, LL.D., F.G.S. (3rd edition, revised), 2/
——— Part 2.—The Phenomena of the Glacial Drift of Scotland. By Sir Archibald Geikie, F.R.S. (*Reprint*), - 5/
Vol. II., Part 1.—Papers on Local and Theoretical Geology, - - 4/6
——— Part 2.— Do. do. do., (*Out of Print*).
——— Part 3.— Do. do. do., - - - 4/6
Vol. III., Part 1.— Do. [contains "On Geological Time." By Lord Kelvin, F.R.S.], - - - 4/
——— Part 2.— Do. [contains "On Geological Dynamics." By Lord Kelvin, F.R.S.], - - 4/
——— (Supplement)—On the Carboniferous Fossils of the West of Scotland. By John Young, LL.D., F.G.S., and James Armstrong, - - (*Out of Print*).
Vol. IV., Part 1.—Papers on Local and Theoretical Geology, - - 3/
——— Part 2.— Do. do. do., - - 3/
——— Part 3.— Do. do. do., - - 3/
Vol. V., Part 1.— Do. do. do., - - 4/
——— Part 2.— Do. [contains "Geological Climate." By Lord Kelvin, F.R.S.], - - - 4/
Vol. VI., Part 1.— Do. [contains "The Internal Condition of the Earth." By Lord Kelvin, F.R.S.], 4/
——— Part 2.—Papers on Local and Theoretical Geology, - 4/
Vol. VII., Part 1.— Do. do. do., - 5/
——— Part 2.— Do. do. do., - 5/
Vol. VIII. Part 1.— Do. do. do., - 5/
——— Part 2.— Do. [contains "Polar Ice Caps and their Influence in changing Sea Levels." By Lord Kelvin, F.R.S.], - - - - 5/
Vol. IX. Part 1.—Papers on Local and Theoretical Geology, - 6/6
——— Part 2.— Do. do. do. - 6/6
Vol. X. Part 1.— Do. do. do. - 6/6
——— Part 2.— Do. do. do. - 7/
Vol. XI. Part 1.— Do. do. do. - 6/
——— Part 2.— Do. do. do. - 7/
——— (Supplement)—Drift or Glacial Deposits of Ayrshire. By John Smith, - - - - - - 4/
Vol. XII. Part 1.—Papers on Local and Theoretical Geology, - - 5/
——— Part 2.—In Preparation.

PALÆONTOLOGICAL SERIES.—Demy 4to.

Part 1.—Containing Four Plates with many Figures, - - - 3/6

CATALOGUE OF WESTERN SCOTTISH FOSSILS.

Compiled for the Meeting of the British Association, Glasgow, 1876.
Crown 8vo, cloth, - - - - - - - - - - - 2/6
The same, interleaved for Notes, and bound in Leather, - - - 3/6

THE GEOLOGY OF THE CLYDE DRAINAGE AREA.

Compiled for the Meeting of the British Association, Glasgow, 1901.
Demy 8vo, cloth, - - - - - - - - - - - 3/

THE GEOLOGY OF THE CAMPSIE DISTRICT.

By John Young, LL.D., F.G.S. Third edition, 1894. Demy 8vo, - 2/

THE PHENOMENA OF THE GLACIAL DRIFT.

By Sir Archibald Geikie, F.R.S. (*Reprint.*) Demy 8vo, - - - 5/

THE DRIFT OR GLACIAL DEPOSITS OF AYRSHIRE.

By John Smith. Demy 8vo, - - - - - - - - - 4/

Copies of the above may be had from the Hon. Librarian, Mr. JAMES S. M'LENNAN, at the Society's Rooms, 207 Bath Street, Glasgow; *or by order through any Bookseller.*

Digitized by Google

THE NEW YORK
PUBLIC LIBRARY
ASTOR, LENOX AND
TILDEN FOUNDATIONS

INDEXED

695455

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. XII.—PART II.

1901-1903.

GLASGOW: PUBLISHED BY THE SOCIETY,
AT ITS ROOMS, 207 BATH STREET.
1905.

Wm. Hodge & Co.,] [*Printers, Glasgow.*

Digitized by Google

PTA

Digitized by Google

Digitized by Google

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

Digitized by Google

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. XII.—PART II.

1901-1903.

GLASGOW: PUBLISHED BY THE SOCIETY,
AT ITS ROOMS, 207 BATH STREET.
1905.

Digitized by Google

The Editor begs to state that the Authors are alone responsible for the facts and opinions contained in their respective papers.

JAS. BARCLAY MURDOCH, F.R.PH.S.E.

Digitized by Google

CONTENTS—Vol. XII., Part II.

PAPER		PAGE
XIII.	The Causes of Volcanic Action. By J. G. Goodchild, F.G.S., of H.M. Geological Survey,	145
XIV.	Notes on the Shoals at Caticol Point and Kirn Point, Arran. By Charles R. Cowie. With a Plate [No. IV.],	156
XV.	Notes on the Geology of the Mediterranean Seaboard. By James Stark,	159
XVI.	Antarctic Speculation. By James Anderson,	167
XVII.	The Physical Geography and Geology of Egypt. By Mathew Blair,	173
XVIII.	The Geology of Portrush. By James S. M'Lennan, *Hon. Librarian*,	180
XIX.	Fresh Points in the Structure of Apiocrinus. By A. L. du Toit, Geological Commission, Cape Town, S.A. With two Diagrams,	187
XX.	On a Volcanic Series associated with the Schists of North Glen Sannox, Arran. By the late William Gunn, F.G.S., of H.M. Geological Survey,	192
XXI.	A Tertiary Volcanic Vent in the Island of Arran. By James Stark, V.P.,	196
XXII.	"Camp Siluria." By Peter Macnair, *Joint Hon. Secretary*. With two Photographs [Plate No. VI.], and a Section,	203
XXIII.	A Stroll along a Trap Dyke in the Parish of Beith, Ayrshire. By James S. M'Lennan, *Hon. Librarian*,	214
XXIV.	Notes on Excavations in Glasgow. By John Wallace,	220
XXV.	The Cambrian Fauna of the North-west Highlands. By B. N. Peach, LL.D., F.G.S., of H.M. Geological Survey. (Summary),	223
XXVI.	The Vertebrate Animals of the Coal Period. By R. H. Traquair, M.D., LL.D., F.R.S., &c., *President*. (Summary),	224

Digitized by Google

PAPER PAGE

XXVII. Notes on a Recent Trip to Egypt. By James Neilson, Milnbank. (Summary), - - - - - - - 226

XXVIII. Volcanoes: their Causes and Effects. By J. G. Goodchild, F.G.S., of H.M. Geological Survey. (Summary), 228

XXIX. The "Green Beds" on Sron Aonaich and near Ardlui, Argyllshire. By Peter Macnair. (Summary), - - 231

XXX. A Theory of the Origin of Columnar Structure as illustrative of Sections near Glasgow. By John Wallace. (Summary), - - - - - - - - - - 234

XXXI. The Origin of Granite. By James Anderson. (Summary), 236

XXXII. Notes on the Geology and Archæology of Syria and Palestine. By James Neilson, Milnbank. (Summary), 239

Proceedings for Session 1901-1902 (44th Session), - - 242

The Report of the Council for 1900-1901, - - - 242

Barbadoes Volcanic Dust exhibited by John Renwick and others, - - - - - - - - - - - 249

The More Important Groups of Carboniferous Plants—1st part—Ferns, *Equisetites* and *Calamites*. By Robert Kidston, F.G.S., V.P. (Summary), - - 246

Analysis of Volcanic Dust. By Mr. Galletly, - - - 250

Proceedings for Session 1902-1903 (45th Session), - - 251

The Report of the Council for 1901-1902, - - - - 251

Address by Dr. R. H. Traquair, F.R.S. Hugh Miller and his Palæichthyological Work. (Summary), - 257

A Day on Ben More, Assynt. By Peter Macnair. (Summary), - - - - - - - - - - 260

Excursions for the Season of 1901, - - - - - - 261

Evening Excursions in 1901, - - - - - - - 264

Excursions for the Season of 1902, - - - - - - 265

Evening Excursions in 1902, - - - - - - - 269

Abstract of Treasurer's Accounts for year ending 30th September, 1901, - - - - - - - - - 271

Abstract of Treasurer's Accounts for year ending 30th September, 1902, - - - - - - - - 272

Digitized by Google

ILLUSTRATIONS—VOL. XII., PART II.

			PAGE
Plate IV.	1. Shoal S. of Caticol Point, Arran, at low tide, looking N. 2. Shoal S. of Kirn Point, Arran, N. shore of Loch Ranza, at low tide, looking N.,	*to face*	157
„ VI.	1. "At work on the Fish-bed," Logan Water, Lanarkshire. 2. "Camp Siluria," Logan Water, Lanarkshire,	„	209
Diagram of *Apiocrinus elegans*, Defrance,			187
Diagram of Section of *Apiocrinus elegans*, Defrance,			189
Section of Structure of the Upper Silurian Inlier of Lesmahagow from Seggholm to Yondertown,			207

Digitized by Google

WILLIAM HODGE AND CO., PRINTERS,
GLASGOW AND EDINBURGH.

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

No. XIII.—The Causes of Volcanic Action. By J. G. Goodchild, F.G.S., F.Z.S., of the Geological Survey, Custodian of the Collections of Scottish Geology and Mineralogy in the Edinburgh Museum of Science and Art.

[Read 9th October, 1902.]*

It used to be a common pastime with schoolboys in the middle of the nineteenth century to rub a brass button of the pattern then in common use upon the surface of either a desk or a form until the button became quite hot. This was done with the object, of course, of surprising another boy by making his neck or arm uncomfortably warm. The weaker or lazier boys were not usually very successful in this amusement, while the more vigorous ones who put a good deal of energy into the work often made the small brass disc so hot that it would make a painful burn when applied to a tender skin. In after years some of those boys learnt the trade of a blacksmith, and in the course of their work had to wield the ponderous sledge-hammer used in fashioning masses of red-hot iron. In moments of leisure, to amuse or entertain visitors to the forge, one or two of them, wielding the same sledge-hammers, would occasionally pound away with all their might upon a piece of well-annealed iron, which, as the hammering went on, became hotter and hotter, until, with skilful handling on

* Part of an Address delivered to the Society at the opening of its 44th Session.

Digitized by Google

the part of all engaged, it became hot enough to set fire to a piece of prepared paper. The grown-up man, of course, put more energy into the work than he could do as a boy. I have been told by a lady who ought to be well-informed in such matters that schoolgirls used to vary the monotony of their daily tasks by rubbing knitting needles on the cloth of their dresses, presumably with the object of seeing which could make the needle warmest, and it was, of course, the girl who put most energy into the work who did this. The point to bear in mind in this connection is that the heat which was generated in each case was directly proportional to the amount of energy expended. Had the girls worked more vigorously they might have made their knitting needles as hot as the least energetic boys did their brass buttons. Had the blacksmiths worked longer and harder they might, with good soft iron, and by not allowing it to get "short in the grain" through the cooling after the process, have made the iron even hotter than they did. All depends, in each case, upon the amount of energy used.

We might pursue the subject still further and call to mind the effects of applying a powerful brake to a heavy train going at a high speed. Or, we might even try to realise what would be the result if two stellar bodies collided, as Dr. Croll has enabled us to do in his "Stellar Evolution." In each and all of these cases it could be shown that there is a direct relation between the amount of energy used and the heat which results. We can, thanks to Joule, now give a numerical expression to the facts: that is to say, if we know what energy has been used, we can state what will be the resulting heat. We can express this in a few words by saying that the energy of motion can be converted into the energy of heat, and that the one is proportionate to the other.

In the cases just referred to it has been assumed that the motion has been more or less rapid, and that in the first-mentioned instance the mass of the body moved was but small. But the same law applies equally well in cases where a very heavy body is moved at a very slow rate. The result, so far as the generation of heat is concerned, might be exactly the same, provided only that the same amount of energy is expended in each of the cases. Hence, if a great mountain mass is slowly undergoing movement by any cause whatever, physicists are able to compute what heat

Digitized by Google

would be generated by the movement at any depth, provided they knew what was the mass of the mountain down to the level under consideration, and provided also that they knew the rate of movement. These data, so far as mountain masses are concerned, are unattainable in the present state of our knowledge; but although we have no means of arriving at any exact figures upon this point, no one whose opinion in the matter is of any worth could doubt for a moment that the law would hold good in this case as much as in those cases which are capable of absolute proof, and in which the result can be stated in definite figures.

That terrestrial movements are still in progress no sane man would be disposed to deny, for the evidence is patent to any one who looks for it. How it is caused is another matter. It therefore seems not a little remarkable that few if any thinkers on the subject have perceived that the temperature of the inner portions of the Earth's crust must be variously affected by these movements. Where the land is perfectly stationary (if any such area exists upon the Earth), the temperature at successive depths below the surface may be expected to represent that which would be arrived at by convection since the time when the temperature of that part may have been higher. This would most likely be, at that period, different for every spot upon the Earth, when the last terrestrial movement there ceased. On the other hand, where terrestrial movements are now in progress, it is no more than we should expect that both the underground temperature and the downward increment of heat would be higher than they are in the parts that are stationary.

It will thus be obvious that observations upon the downward increment of heat, and the temperature of the rock at any given depth, must both necessarily vary with local circumstances, being highest where movements are in progress and lowest where they are not. It is to causes of this nature that I should be disposed to attribute the abnormal temperature of the lower parts of the water in the Lake of Geneva, as well as that in other areas which are, or lately have been, affected by terrestrial disturbances.

I am therefore disposed to regard the higher temperature met with below the Earth's surface as due mainly to dynamic causes lately in operation, or else to the vestiges of those which were in operation there in the not-remote past. Furthermore, if this

Digitized by Google

line of reasoning is sound, there does not seem to be any necessity for supposing that the innermost parts of the Earth may be any hotter than the parts nearer the surface. They may not be even as hot, for, if the high temperature within the Earth's outer envelope does really result from dynamic causes, the zone of highest temperature must lie at a comparatively small depth below the surface, and may, indeed, reach its maximum at the depth of only a few miles. Whether any of the heat found within the Earth's crust represents vestiges of the original incandescent mass from which the Earth has cooled is a point upon which opinions may differ, and upon which, I venture to think, nobody can feel absolutely sure.

If this point—that part of the high temperature existing within the Earth's crust is due to dynamical causes—be conceded, we may pass on to consider whether there is evidence of any important movements of recent date, geologically speaking, and, if so, what relation these bear to the existing inequalities of the lithosphere. In this connection we must carefully distinguish between (1) those broader uplifts which elevate large continental tracts and which do so with a near approach to uniformity over large areas, and (2) those other undulatory movements which result in marked differences in elevation within a comparatively narrow zone. In the former case both the period and the wave-length of the undulation may be long and the amplitude be low, while, in the other case, both the period and the wave-length may be short, while the amplitude of the undulation may be high. It is with cases belonging to the latter category that we are more especially concerned in this Address.

That important changes of level have occurred upon many parts of the Earth in quite recent geological times is a fact well-known to even the tyro in geology. We have but to think of the enormous changes and disturbances which have affected the land since a date so comparatively modern as the Miocene Period to be convinced of that. And when we come to review the evidences afforded by sea-bottoms which have been upheaved, even since the existing species of mollusca have come into existence, of which there are so many striking proofs in various parts of the Earth, and especially within the Mediterranean region, we may well pause before regarding the more recent ages of the Earth's history as being those of comparative stability.

Digitized by Google

A powerful confirmation of the views of those who (like myself) have never had any faith in the doctrine of the permanence of the ocean basins and continental areas, has lately been advanced by Prof. Alex. Agassiz. In an address on Coral Islands given by him before the Royal Society of Edinburgh, he showed that nearly all the upraised coral reefs of the Pacific area (and, indeed, of other areas as well) were based upon deposits of deep-sea origin formed in late Tertiary times, and have been since upheaved. There is no gainsaying that fact: and a most important one it is, not only in connection with the evidence of wide-spread undulatory movements of the Earth's crust within recent times, but also because it effectually disposes of the argument that the ocean and continental areas have been such from the beginning. I will not here dwell upon the fact, that ancient radiolarian oozes *which contain no traces of calcareous organisms* * occur here and there throughout many parts of continents which are now situated far from the oceans, and that these are now known of all geological periods down to quite recent times. Enough, I think, has been brought forward to show that important terrestrial movements have recently affected many parts of the Earth's surface.

The next point to consider is whether any of these areas which have recently undergone important changes of level show exceptional inequalities in regard to the amount of upheaval over narrow zones: in other words, whether they come under the second category mentioned above. As an answer to this may first be cited the marginal area of the Pacific. Within this area a mere cursory examination of any good physical maps giving heights and depths will at once show that these conditions are present around nearly the whole marginal areas. Deep—in some cases very deep—areas of sea-water are again and again found in close proximity to slopes of the lithosphere which are of exceptional steepness, and which are prolonged above the sea-level in many instances to elevations of thousands of feet. On the crest of the culminating ridge in such cases there usually occurs a line of volcanoes, and the country far inland is liable to frequent and often violent shocks of earthquakes. Besides the

* The mere occurrence of radiolaria in a given rock affords no proof of the depth at which the original sediment was found *unless* calcareous organisms are very rare or absent.

Digitized by Google

Pacific area just mentioned, illustrations might be taken from the Mediterranean, the West Indian area (to be again referred to), or from the eastern side of the Indian ocean.

Is it not evident that there is some connection between these steep slopes of the lithosphere and recent undulatory movements affecting the larger features of surface relief of the area in question? Is it not also suggestive of the existence of some connection between these recent earth-movements which, by dynamic causes, have generated the heat manifested in connection with the marginal belt of volcanoes? Further, and lastly, does there not appear to be an evident connection between the enormous volumes of steam emitted by volcanoes, on the one hand, and the fact that the solid products of volcanic action differ in composition from sedimentary rocks mainly in the percentage of alkalies present in each case—does it not seem as if the proximity of large bodies of water containing alkaline matters in solution also had something to do with the causes of volcanic action? I think that they have. It seems to me, indeed, that it is along the septum, as Prof. Lapworth terms it, between areas undergoing depression below sea-level, and others adjoining which are undergoing upheaval, that all the conditions are present which are requisite for the generation of volcanic action. Just as in biological matters it is the transition area between the margin of the land and deep water which is the area of greatest activity in matters pertaining to life, so also is it along that same marginal or transitional zone that there lies the area of greatest terrestrial activity. Assuming, therefore, that, except in matters of opinion, most of the foregoing statements will be accepted as in accordance with the facts, I shall go on to present what I take to be the sequence of events in connection with volcanic action, and shall state them in yet another form.

When rocks upon the land undergo weathering they are changed into two states: in the one, part of the materials, largely consisting of soluble carbonates of the alkalies and alkaline earths, is carried seawards in a state of solution: in the other we have the solid residues from which these alkalies and alkaline earths have been, temporarily, divorced. The ultimate destination of both is the sea: the former going into sea-water in a state of solution, and the latter sooner or later being left upon the sea-

Digitized by Google

bottom as sediments. A bulk analysis of these sediments, taken one with another, compared with a bulk analysis of any rocks of eruptive origin, shows that the two differ mainly in the percentage of alkali present. There is much alkali in the eruptive rock, and but little in the other. Hence no amount of metamorphic change could ever transform sediments of any kind into eruptive rocks; unless, of course, that change takes place through the addition of the alkaline substances previously wanting. The alkalies must be in solution, and the change from the one state to the other would be greatly facilitated if the process be carried on under great pressure and at a moderately-high temperature. Time is, of course, an important factor in all processes of this nature.

Sea-water contains, in addition to many other substances, the alkalies divorced from the parent rocks upon the land. If there were any means of concentrating these solutions by expelling part of the water, as might be done by prolonged evaporation, such sea-water, with part of the water boiled out of it, would answer all the purposes required for the transmutation above referred to. Prolonged exposure to a solution of this nature can only end in the re-combination of the two essential constituents into a new rock, agreeing in composition with some rock of eruptive origin. It has to be remembered in considering the subject of the causes of volcanic action, with this factor in mind, that water at a moderately-high temperature and under a comparatively low pressure is competent, alone, to dissolve many rock-constituents; and, if alkaline matters are present in solution in those thermal waters acting under pressure, the solvent action is greatly increased, and can operate at a much lower temperature.

On the other hand, it appears that increase of pressure beyond a certain point prevents solution, just as an increase of pressure raises the boiling point of water.

If, therefore, any mass of rock is so situated with regard to temperature and the presence of alkaline matters that it is ready to pass into a state of solution, the tendency to do so is hindered, or may be checked entirely, by the influence of pressure. If a temporary relief of pressure supervene under these conditions, however, solvent action will immediately set in, and the whole compound may pass into the condition of an aqueous solution at all the points where the pressure has been eased off to the extent required.

Digitized by Google

From these considerations it will at once be evident, I think, that all that is required for the production of volcanic phenomena is the heat generated by dynamic causes, together with access of abundant sea-water.

It is a well-known fact that heated rocks absorb or occlude larger quantities of water in proportion as their temperature rises. Whether part of the water thus occluded becomes dissociated into its component gases under these conditions does not appear to be yet known with certainty. But there are reasons for believing such to be the case. Following our German fellow-workers, we may refer to this as "water-stuff," $2\ H_2 + O_2$. The question is one of some importance, because combination with the dissociated oxygen may take place under these conditions to a considerable extent, and in that case it is well known that the temperature of the mass affected would be further raised, and that to a very important extent. Thus, as it seems to me, if once these conditions are started, even over a very small area, the tendency would be for the elevated temperature to extend over larger and larger areas adjacent.

Now let us consider what would happen on the supposition that some definite area, such, for example, as the Windward Islands, where the recent disastrous volcanic eruptions are still (1902) going on, is the theatre of important movements of the Earth's crust. The facts clearly show that this chain of islands represents what was formerly a sub-oceanic ridge, which is now being squeezed up between two great oceanic depressions parallel to it. The depression on the west side of these West Indian, Antillean, or Windward Islands, runs down within a short distance from the coast-line of the islands to depths of between nine and ten thousand feet, while that on the east side descends with hardly less steep a slope to nearly the same depth. I should regard each of these lateral depressions as correlative to the elevated area between: all three being merely different phases of a series of terrestrial undulations which have been lately in progress. Dynamic causes operating on such a scale must necessarily give rise to an elevated temperature within the terrestrial envelope, even though the rate of movement may be slow, as measured by the ordinary human standards of time. Sea-water, charged with the substances brought down in solution

Digitized by Google

from the land, makes its way downward through the strata which support the floor of the ocean, being aided in this, I think, by osmotic pressure in the first instance. Coming nearer to the zones of high temperature generated by earth-creep, the water, carrying with it its dissolved constituents, begins to be affected by occlusion, and combines in this way with its associated rock-constituents to form a dangerously-explosive compound, at the same time tending to dissolve the rock-constituents themselves, and to add alkalies to the whole mass affected.

Pressure checks the process for a time; but, during the period when lateral compression is in operation, the rocks now and then give way more or less abruptly at one or two points. This occasions a local relief of pressure, which in turn permits of part of the imprisoned water flashing at once into steam. It also permits of the liquefaction of some of the rock-material, and it may set up other changes, all of them conducive to the generation of volcanic action.

This subterranean explosion is the fundamental cause of an earthquake, which not only shakes the surface with more or less violence, but operates also upon the rocks around, and especially upon those above the area where the explosion originated. In fact an earthquake operates in much the same way as a powerful blast of dynamite or gunpowder does in the case of the rock in a quarry. In either case the cohesion of the rocks is loosened to an extent proportionate to the violence of the shock. In that specially under consideration the pressure is further relieved, and, as a consequence, more $2\ H_2 + O_2$ re-combines to form high-pressure steam, at an enormously-high temperature, and occasioning still further shocks by the energy set free in the process. Once commenced, the action tends to go on, and to increase both in magnitude and in the extent of the area affected; always, however, affecting higher and higher levels as the process extends, until, at last, a violent earthquake shock affords a point of relief near the surface, and a volcano starts into existence.

It will be noted in considering this statement, that I think the high temperatures characteristic of volcanic materials, when they reach the surface, are maintained, if, indeed, they are not largely augmented, by the heat of combination of the dissociated "water-stuff," as well as of that part of the dissociated oxygen in the case

Digitized by Google

of the various oxygen-compounds which are being produced as a result of plutonic action.

The explosive action of superheated steam and "water-stuff" is not the sole agent concerned in propelling volcanic material to the surface, for the mechanical effect of a lateral thrust must also play an important part. This, of course, operates upon the softened rock-material in much the same manner as happens when we squeeze a tube of oil-paint in order to force out some of the contents. There must usually be, as a result of this, a flow of rock-material below the surface towards the focus of volcanic action from the more solid rocks around; and this movement in its turn also gives increased facility to volcanic action in the manner already referred to.

The quantity of water occluded must vary much with the nature of the circumstances in each locality. In some it may remain, as it were, stored up within the rocks, which thereby become very dangerously-explosive mixtures of superheated water and dissolved rock-constituents, as was the case in the eruption of Mont Pelee. In other cases the water may be kept, as it were, on the boil, and thus evaporated to an important extent. The effect in that case, however, would be simply to concentrate the materials held in solution, which, whether they originate from sea-water, or from the water of saline inland lakes, contain in either case the very substances which are needed in order to bring about any conversion of sediments into eruptive rocks.

It will be noted that there is often a curious connection traceable between the recurrence of arid climatal conditions with the resultant saline lakes, on the one hand, and the evolution of volcanic action on the other. The cause is, I think, the downward percolation of alkaline waters to heated zones within the Earth's outer envelope.

The essentials for the generation of volcanic action, therefore, are, according to this view (1) undulatory movements of the crust of the Earth sufficiently marked to give rise to steep slopes of the lithosphere, whereby heat is generated; and (2) the presence of large bodies of water charged with alkalies. A glance at any good physical map showing heights and depths, together with the geographical distribution of volcanoes, ought at once to convince

Digitized by Google

any thoughtful person that this association is something more than accidental. Furthermore, we might regard the deep depression of the Bay of Biscay as being formed contemporaneously with the volcanoes of Olot. We might indeed go further, and speculate whether the position of the 100 fathom line west of Britain may not have been determined by the causes to which our Tertiary volcanic rocks were due. Going still further back in time we might even speculate upon the position of the areas of deep sea during the time when our Carboniferous, or even our Devonian volcanoes were in activity.

It will probably come to be generally recognised before long that the uprise of thermal waters charged with alkalies has played a very much more important part in bringing about changes in the composition of rocks than most persons are, at this date, willing to admit.

I have already laid before this Society my reasons for believing that there is no such thing as an igneous rock. All rocks so-called are, according to my view, simply deposits from heated aqueous solutions—not of course in the sense in which our forefathers employed this expression, but in the sense in which I have used it in this Address.

Furthermore, the same factor has probably played an equally important part in metamorphic action, especially in the generation of many gneisses which, in many cases, may be simply old sediments to which alkalies have been added.

Lastly, the curious association often observable between gabbros and granitic rocks which present a granophyric structure, is, I think, just as likely to have arisen as a consequence of the uprise of thermal waters containing compounds of silica and potash through the older basic rocks (which may be old basalt lavas, dykes and sills, further re-crystallised in the core of an old volcano). Such action would, I venture to think, add to the basalts the constituents requisite for the formation of a more acid type of rock which were previously wanting, and would thus lead to their conversion wholly, or in part, into a rock with the composition of granite. Many facts suggest that this is the true explanation of phenomena which have never yet been satisfactorily explained by any other hypothesis which has been put forward.

Digitized by Google

No. XIV.—Notes on the Shoals at Caticol Point and Kirn Point, Arran. By Charles R. Cowie. With a Plate (No. IV.).

[Read 11th April, 1901.]

Between Loch Ranza and Caticol, and just south of Caticol Point, there is a considerable shoal formed of blocks of rock and shingle which is only exposed at low water, and is then seen to be covered by a strong growth of long seaweeds. It extends southwards for about 300 yards, and is separated from the gravelly sea-beach by a shallow and sandy channel.

It has often been assumed that the boulders forming this shoal are of granite and slate, which have been transported down Caticol Glen or Loch Ranza Glen, and the grey coating on many of them, caused by the growth of barnacles, has doubtless led to this supposition. A casual look at the stone walls in front of Caticol Farm, near the shoal from which I ascertained the materials had been obtained, showed that they contained many blocks of red limestone, some much perforated by borings of the *Pholas*.

I was therefore induced to make a careful examination of the shoal itself, and on doing so I found that, while there are a few granite and slate blocks, and these amongst the largest, the great mass of the collection consists of fragments of red limestone, red and grey sandstone, quartzite, dolerite, and conglomerate, of all sizes, large and small. Nearly all of them are angular, and they lie mingled together in the most indiscriminate way.

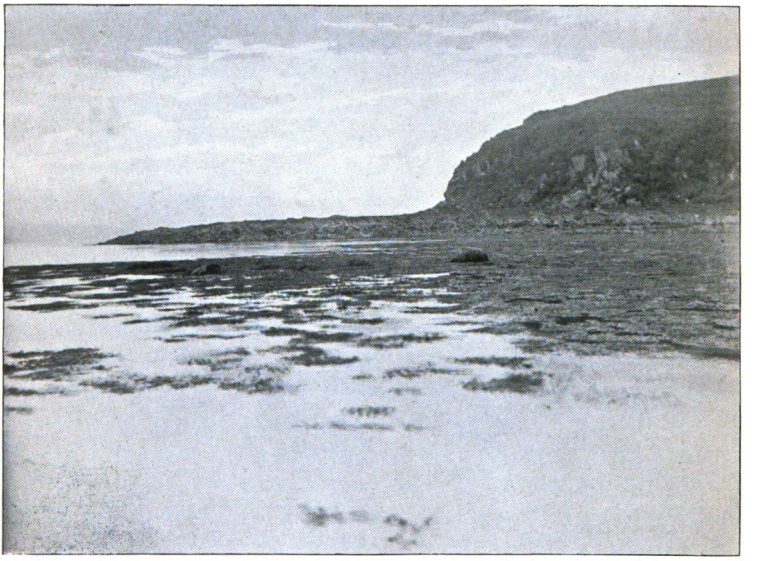
Some of the specimens of these rocks which are now exhibited will give a good idea of their characteristics. The massive red limestone, carrying in many instances the smooth perforations of the *Pholas* borings, and containing numerous examples of *Productus* and other molluscan shells, is probably the most plentiful, and there is a more shaley red limestone which is literally packed with organic remains, particularly crinoidea, which are much broken and crushed, and polyzoa. There are also specimens of conglomerate, breccia, quartzite, grey and red sandstone, and one nodule of reniform or kidney-shaped hematite.

The red limestones and sandstones, as well as the breccia, correspond with the rocks found along the northern shore of the

Digitized by Google

Digitized by Google

I. Shoal S. of Caticol Point, Arran, at low tide, looking N.



II. Shoal S. of Kirn Point, Arran, N. shore of Loch Ranza, at low tide, looking N.

From Photos by John Cowie. *Hislop & Day, Photo Engrs.*

Digitized by Google

island, but the latter may have come from Newton Point. There are no similar rocks nearer *in situ.*

It is therefore probable that the stones forming the Caticol shoal have been brought from the north by ice and deposited as a moraine in the position which we now find them occupying. The mass of the ice on its way southward has pressed round Caticol Point, and has then gone straight across the mouth of the bay to Lennimore Point, probably pushed outwards by the ice-floe which came down Caticol Glen. The time when the shoal was deposited must have been somewhere near the termination of the glacial period, as the pressure of the two ice-floes must have left the northern corner of the bay behind Caticol Point free from covering, and the collection of debris was consequently laid down there as a lateral moraine.

The outer edge of the shoal corresponds to a line drawn between Caticol Point and Lennimore Point, while the inner edge follows the curved line of the shore, the general area being thus somewhat fan-shaped, with the broader end towards the south. There is always a shallow depression between the inner edge and the curve of the shore.

At first I thought that this shoal might mark the site of an out-lying deposit of the red limestone, or of the breccia, similar to that at Newton Point, where the patch of the latter rock rests unconformably on the slate, but no evidence of the existence of such a bed *in situ* could be detected, besides which the very mixed character of the deposit itself made the idea rather improbable.

It is somewhat surprising to find these comparatively soft and friable rocks remaining in the condition they are, after so long an exposure to the gales on this open beach, but of course they are sheltered from atmospheric influences except at low tides.

The sea-beach lying inside the shoal in Caticol Bay is composed, at and about high-water mark, of granite and slate shingle much rounded and water-worn, and these are essentially different in character from the angular fragments of which the shoal is built up.

The shoal at Kirn Point, on the north shore of Loch Ranza, has been often believed to be composed of granite or slate blocks, but the same conditions which are apparent at Caticol will be found

Digitized by Google

to have prevailed there also, though in a modified form. Boulders, seaweed and barnacle-covered, and so having a very granitic appearance, were found in many cases to be of limestone, sandstone, or breccia. I was unable, however, to detect any specimens of the shaley crinoidal limestone, but all the other rocks found in the shoal at Caticol were in abundance. The blocks are lying mostly towards the outside, or western side, of the shoal, although some were more generally distributed. Several boulders of sandstone were seen half-way up the loch, and fragments of limestone, containing *Productus* and plant-remains, were observed in the gravel pit at Ballarie, a mile up the glen, and just below the fifty-feet level. Specimens of these now exhibited will show their characteristic features. A fair proportion of the blocks have come down the glen; the sandstones and limestones from the top of the hill above the Cock of Arran where the outcrop of the rock occurs, some having been dropped at intervals by the way; the slates came from Glen Chalmadale, while the granites have been carried from Eis-an-Biorach.

Judging from the position of these shoals in relation to the crags lying to the northward, I think there is a strong probability that they were deposited when the ice, and therefore the sea, was at the level of the old ten-feet raised shore-line, and that the action of the ice-floes, rather than that of the water, eroded the rocks along the coast-line, leaving the lower rocks in front so neatly sheared off all along it. The longer lines of the two lateral moraines here described coincide very nearly with those of the crags which lie to the north of them.

Digitized by Google

No. XV.—Notes on the Geology of the Mediterranean Seaboard. By James Stark.

[Read 12th December, 1901.]

Having recently had occasion to make a journey to Egypt, *via* Marseilles, Tunis, Palermo, Syracuse, and Malta, returning homewards by Brindisi and the Mont Cenis tunnel, I bring before you a few notes and specimens, geological and otherwise, picked up on the way, in the hope that they may prove of interest.

The entire basin of the Mediterranean, greatly more than a million square miles in area, appears to be largely composed of white, grey, and yellow limestones, of Jurassic, Cretaceous, and Eocene ages; not, as a rule, much disturbed from their original horizontal position, though occasionally flexed and tilted to high angles, and even inverted, as in some parts of the Alps. As these limestones are composed largely of the shell-cases of minute organisms, foraminifera, &c., while their combined thickness must amount to some thousands of feet, what a picture they present to the mind of the vast lapse of time during which "the stillness of the central sea" must have prevailed over this immense area, while the milky ooze accumulated on the sea-floor as slowly as the dust falls in a disused room.

The shores of the South of France are composed of lofty hills of hard, white limestone, in which, as used in the dock-walls of Marseilles, may be seen the graceful whorls of the ammonite and nautilus. Through these hills the Rhone has cut a deep valley, now utilised for the passage of the railway to Marseilles, which affords fleeting glimpses of many fine sections, but denies the opportunity of examining them. The bare white bones of Mother Earth protrude everywhere through the thin skin of soil, yet French thrift has made the best of the situation, and, except where the slopes are too steep, the hillsides are clothed with vines and fig-trees. For a considerable distance from the present shore may be seen traces of old beaches of rounded gravel, with beds of clay in sheltered nooks, in which numerous brickworks turn out high-class goods like terra-cotta ware.

Sailing from Marseilles, we find that the slopes of the hills to the eastward, as far as they can be seen, are abruptly truncated, and

Digitized by Google

descend sheer into the sea in lines of broken white cliffs. A group of islands which form a natural breakwater to the harbour, and bristle with long guns for its defence, show similar evidences of extensive marine erosion.

Crossing to the northern coast of Africa, we come to Tunis, the site of ancient Carthage, at the bottom of a deep bay, flanked on either side by parallel spurs of the Atlas range of mountains, which here attain an elevation of from 3000 to 4000 feet, and are composed of white nummulitic limestones of Eocene age. Between the city and the sea extends a wide and dreary expanse of salt-marshes and shallow lagoons, through which French enterprise has cut a long ship-canal, leading into a wide basin, which seems needlessly large for the three or four steamers lying at the wharves. A heap of broken galena awaiting shipment reminds one that the lead-veins of the Atlas Mountains were worked by the Romans more than 2000 years ago.

Crossing again to the northwest of Sicily, we find a bold coast-line of lofty mountains composed of the same white limestone, and presenting to the sea a line of broken precipices with a talus of debris along their bases, which, in the meantime, protects them from further erosion. In a deep bay flanked by tall cliffs lies the harbour of Palermo, the finest in Sicily, whence a railway crosses the island to Catania and Syracuse. For the first thirty miles this line runs eastward along the coast, skirting the foot of a range of hills of white limestone. The soil is thin, poor, and full of angular stones; yet it supports a profusion of orange and olive trees. Turning inland, the railway ascends, by steep gradients, a valley which presents many interesting sections, the prevailing feature being thin bands of white limestone inter-bedded with thick beds of incoherent marls, reminding one strongly of the well-known Ballagan beds of the West of Scotland. The strata are much disturbed, and bent into all sorts of synclines and anticlines. The hills assume the familiar rounded and flowing outlines of our own southern uplands; and the lower parts of the valleys present, in the beds of streams, numerous sections of a deposit with all the appearance of Boulder-clay, which contains many rounded white boulders, as large as a man's body, sticking out of the "scaurs."

This portion of Sicily was one of the great granaries of ancient

Digitized by Google

Rome, and it is up to the present a grain-producing district, the hills being cultivated to the very summits. Great care is taken to pave the numerous watercourses on the hillsides with blocks of limestone, so as to prevent the rich soil from being washed away by flood water. The railway here mounts to an elevation of 1600 feet above sea-level, as measured by a pocket aneroid, and then descends to 1000 feet, after passing over some fifty miles of rich corn-lands, the soil of which is due to the disintegration of the soft marls. The compact limestones again re-appear about the middle of the island, and heaps of smelted sulphur are seen at the stations; numerous columns of smoke and long red screes on the hillsides marking the positions of the mines and smelting-works. Sicilian sulphur ore occurs associated with limestones and marls of Eocene age, and contains from 25 to 30 per cent. of the mineral. It is mined from "ingaun-ees" on the stoop-and-room principle, and smelted in pits dug out of the hillsides. In default of other fuel, a proportion of the ore serves to smelt the rest; only about half the available amount of sulphur being recovered in the process. One naturally associates Sicilian sulphur with Mount Etna, but as that mountain rests on deposits of late Pliocene times containing recent shells, with bones of elephants and extinct mammalia, the sulphur must have been there long before the volcano. The mines and smelting-works are seen on the hills for the next forty miles, in which the railway rises to 1900 feet, passing through a wild, mountainous country in which beds of massive limestone cap the hilltops, and the soft marls are hollowed out into deep valleys.

Descending the slope, as the valley through which the railway runs opens out towards the plain of Catania, the magnificent bulk of Etna appears on the left, flecked with snow towards the summit, and with rapidly-changing masses of fleecy cloud, or steam, it may be, playing about the truncated cone and shoulders of the mountain. The outstanding feature of Etna is its enormous breadth of base, and the very gentle slope of its sides. The base is approximately a circle of over 80 miles in circumference, and covers an area more than three times that of the entire island of Arran, while its truncated top is four times the height of Goatfell. Another feature which quickly strikes the eye, is the large number of conical craters, stuck, like warts, all over the slopes of

Digitized by Google

the mountain. No less than 200 of the largest of these have been mapped, and some of them are as large as Arthur's Seat.

Although Etna has never been quiescent since the dawn of history, only one of these parasite cones is known to have been formed during that period, viz., in 1669. This eruption commenced by the opening of a vent on the lower slope of the mountain above Catania, from which scoriæ and ashes were thrown up in such quantity that a cone 450 feet in height was formed in a few months; then a fissure a couple of yards wide is said to have opened with a loud report, stretching from near the new cone for a distance of 12 miles towards the summit of the mountain. From this fissure a bright light was emitted, indicating that it was filled with molten lava, and giving an idea of the origin of the dykes that are so common in Scotland. The lava did not rise to the surface at the fissure, but burst from the newly-formed cone, which was on a lower level, and poured down the slope in a fiery torrent, overflowing more than a dozen villages in its track. Meantime the inhabitants of Catania had been working hard to raise the lower parts of the walls of their city, but in vain, for the burning flood accumulated till it rose over the top of the rampart, said to have been sixty feet in height, and fell in a fiery cascade, overwhelming the lower parts of the town.

Another eruption in 1852 flowed for nine months and produced a bed of lava 6 miles long by 2 broad and 30 to 50 feet thick, which was said to have been like a sea of fire. Etna has probably never been quiescent since its foundations were laid when it commenced business—how long ago? According to Lyell, the marine clays, with which the oldest of its ashes and lavas are associated, contain shells, 95 per cent. of which are of living species, and he consequently dates its origin subsequent to the commencement of the glacial period. If Croll's calculations are reliable that may be about 200,000 years ago, and yet that is only yesterday as reckoned by geological time.

The valley now opens on the great alluvial plain of Catania, sloping insensibly down to sea-level, from about 50 feet above it, and apparently a recently-elevated river delta, like many of our Scottish carses. Crossing the plain, we find the compact white limestones re-appearing in the form of a plateau,

Digitized by Google

which presents cliffs about 50 feet high towards the sea, and is evidently a plain of marine denudation, indented with many a deep bay. The bottoms of these indentations, once the beds of ancient rivers, are now mostly occupied by salt-pans, where salt is made by evaporating shallow water enclosed in mud embankments, by the heat of the sun.

At length the train steams proudly into Syracuse, having accomplished the distance of 180 miles from Palermo in eleven hours, an apt illustration of the Italian proverb, *Festina lente*—"hasten slowly." There is much to be seen in Syracuse, redolent of Dionysius, Archimedes, and Paul the Apostle; but the steamer waits for us, and we start for Malta in company with a Yankee archæologist in quest of ancient coins, who complains bitterly of a guileless peasant trying to sell him an American cent!

Malta is the largest of a group of islands situated on a ridge which stretches across from Sicily to Tunis, over which the water is comparatively shallow, the deepest sounding being about 1000 feet. This ridge divides the Mediterranean into two basins, each attaining a depth of about 12,000 feet. The island of Malta is about the size of Arran, and is composed entirely of nearly horizontal beds of limestone and soft marly sandstone of Eocene age. On the south and west the coast is bordered by cliffs rising sheer from the sea to a height of 300 to 400 feet. On the north and east the land is much lower, and the cliffs are interrupted by several deep indentations and bays. The surface is diversified by hills and valleys which must have been excavated by running water, although there is now not even a small stream in the island. The upper parts of these valleys are truncated by the tall cliffs on the south, while the bays on the north and east are evidently lower portions of the same valleys now submerged, like many of our own Highland lochs. In short, the Maltese islands are but the broken remains of an extensive tract of land, which not improbably was once a portion of the African continent, first partially submerged till the sea invaded the mouths of its river-valleys, and then denuded by the waves until only a few fragments remained, like the cones of earth left in an excavation by navvies to mark the extent of the material removed.

The harbour of Valetta, the capital of Malta, is entered through a narrow gap in a line of low cliffs, and divides inside into five

Digitized by Google

deep, narrow bays, excavated out of the horizontal limestones, with steep-sided promontories between, in plan not unlike the fingers of a hand. These can be nothing else than the valleys of five ancient streams, which, having lost their head-waters through the disappearance of the ancient high lands behind them, do not now exist.

The shores of Egypt present a striking contrast to those parts of the Mediterranean seaboard already described, consisting, as they do, except on the Nile delta, of wide plains of shifting sand, drifted into swelling dunes, like waves of the sea. Inland the country gradually rises into a rolling plateau, more or less covered with drifts of sand, but with numerous exposures of the nummulitic limestone beneath, as, for instance, the rock out of which the famous Sphinx has been hewn. Further inland the limestone gives place to the Nubian sandstone, and through the sandstone, at the cataracts of the Nile, protrude masses of red granite and other primitive crystalline rocks, which rise towards the east into lofty mountains on both sides of the Gulf of Suez, those on the farther side being the famous mountains of Sinai. There can be no doubt that it is to the prolonged sub-aërial denudation of these crystalline rocks that the sands of the deserts of Egypt and Arabia are due. Blown about by dry winds for ages, the grains of quartz of which they are composed are comminuted, rounded, and polished, in a way that could not have been done by any other agency.

Everywhere the shores of the Mediterranean show evidence of recent changes in the relative level of sea and land. The front of the Rock of Gibraltar presents several terraces at different levels, with sea-worn caves. Near Marseilles beds of brick-clay, gravel, and conglomerate, occur at various levels, with perforations of *Lithodomi* in the limestone, some containing the shells still undecayed. Numerous inland cliffs with caves, and the plain of Catania in Sicily, confirm the evidence of recent elevations of the northern coasts of the Mediterranean; as does also a plain of marine denudation, some 50 feet over sea-level, which extends for many miles along the east of Sicily, and almost the whole length of the east coast of Italy. On the other hand, the wide salt-marshes of Tunis filling up an ancient estuary, the submerged river-valleys of Malta, and the numerous mounds enclosing ruins

Digitized by Google

of ancient buildings rising above the surface of lagoons along the coast of Egypt, tell a tale of recent depression along the southern shores; though the southern shores of the Isthmus of Suez have been recently elevated. There can be no doubt that the Gulf of Suez once extended into the Bitter Lakes, much farther north than it now does, and the crossing of the Israelites in all probability took place between the Bitter Lakes and the present head of the Gulf of Suez, which is now dry land, and where shells of recent species are plentiful among the sand.

Returning homewards, we observe that such of the islands, and portions of the mainland of Greece as can be seen from the steamer, present the same aspect as the other limestone districts already described. Similar white cliffs along the shore rise inland into similar hills, which are so bare of soil that the bedding of the limestone can often be followed for miles. These suggest the thought of our great indebtedness to the ancient glaciers which ground down the naked rocks of Scotland as in a mill; so that now, if we cannot boast of so genial a climate, we have at least a far superior soil to that of most parts of the countries bordering the Mediterranean Sea.

The railway from Brindisi runs on a plain of marine denudation which skirts the eastern seaboard of Italy, except where interrupted by the sandy beds of its many broad estuaries, and affords glimpses of the, sometimes snow-capped, Appenines on the left, and the blue waters of the Adriatic on the right. The prevailing rock is still the hard white limestone, with a very scanty covering of soil, which for many miles affords a precarious support to an endless succession of old doddered olive trees, which appear to subsist on a soil too poor for anything else to grow.

Leaving the seaboard at the head of the Adriatic the railway gradually climbs the slopes of Piedmont towards the Alps, the gradients becoming steeper as it creeps up the side of a deep valley, with a river about the size of the Clyde toiling among the boulders at the bottom. The scenery is wonderfully like that of the Scottish Highlands, only on a much larger scale, the valleys having visibly been carved out of mountain masses of limestones of late Secondary and early Tertiary ages, in some places not much disturbed, but in others crushed, folded, and metamorphosed like the Highland schists. The lower slopes of the valleys are carefully

Digitized by Google

cultivated, the hillsides terraced and laid out as vineyards, but as we ascend towards the tunnel, which, according to the aneroid, is nearly 4400 feet above sea-level, or about the height of Ben Nevis, the Scotch fir, larch, and birch take their place, with a great profusion of wild roses. Up to the snow-line, which may be 4000 feet higher, white and grey limestones are strongly in evidence, and even the jagged peaks at the sky-line, bare, because too steep for the snow to lie on them, appear to be sculptured out of the same materials.

Passing through the Mont Cenis tunnel, which is 7½ miles in length, the train emerges in France at a lower level by some 400 feet than where it entered the other end on the Italian side, the time occupied in passing through being twenty-three minutes. Here the scenery and rock-formation are very similar to those already described on the Italian side of the Alps; the railway descends through long valleys cut out of the massive limestones by brawling streams which are seen hastening to join the "arrowy Rhone."

Leaving these behind, we now cross the central plateau of France, and after a railway run of two days from Brindisi, come to the chalk-cliffs skirting both sides of the English Channel, thinking the while how true a geologist was the man who first spoke of "*auld* Scotland." Compared with our own Scottish mountains the Alps and the Appenines are plebeians of yesterday, and we may take a pardonable pride in the fact that our country presented its bold features to the light of heaven for untold ages, during which the greater part of the rest of Europe was at the bottom of the ocean.

Digitized by Google

No. XVI.—Antarctic Speculation. By James Anderson.

[Read 8th May, 1902.]

The unwonted zeal with which Antarctic exploration is being taken up at this time has suggested to me that we might usefully air any theories which have been fruitlessly simmering in our brains, and let explorers know what information would be specially acceptable to us. Fine theories are useless while there is no hope and no opportunity of putting them to the test, but when explorers come forward ready to throw new light on the cheerless Polar regions we may find our musty ideas take on new life.

One of the most important subjects on which fresh light may be shed is the formation of Boulder-clay. I think I may safely say that no other geological material has received so much attention from the members of this Society. In that we are perhaps victims of circumstances, for in the West of Scotland it stares us in the face wherever we go. While the deposit itself is a very solid indisputable fact, the true method of its production has, in my opinion, still to be determined. We all admit that it was formed by ice, but how the ice did actually form and deposit those great beds is not so evident. Any of the great glaciers of to-day which admit of inspection show no signs of Boulder-clay. They all without exception originate on high ground, and from their very birth commence to move downwards; which movement never ceases till they become exhausted. In their course they break up large quantities of rock, grinding much of it into mud, and from under every one of them there flows a mud-laden stream. The rough debris of the broken-up rocks, after being carried down, is thrown on a terminal moraine, while the river disposes of the mud, and so far as can be seen no deposit is being formed under the glacier itself.

When we examine a bed of Boulder-clay it is quite apparent that it has not parted with any of its mud, from which we may infer that the glacier which formed it never had a river running underneath it. Further, as mud is an essential constituent of Boulder-clay, we may argue that no sheet of ice with a river flowing below it could ever have formed such a deposit.

I will now give my idea of an ice-sheet capable of forming

Digitized by Google

Boulder-clay. Let us take the basin of the Baltic for illustration, with the temperature so low that its whole extent remained permanently frozen over, as it is of course necessary for my purpose to pre-suppose a decided lowering of the average temperature. After the ice has ceased to thaw with the summer heat it would become thicker every year, and with the progress of time through hundreds of years the sea would become filled with a solid body of ice with no water underneath. This thickening would not take place from below, but would result from the accumulation of snow on the surface producing a growing thickness of ice which would settle down on the bed of the sea and eventually squeeze out all the water from beneath. Given a sufficient length of time, such an ice-sheet would grow until it spread over the surrounding low districts, and there would be nothing to hinder it growing until it attained a thickness of 2000 to 3000 feet, one which we have been in the habit of reckoning necessary to account for the familiar evidences of glaciation and Boulder-clay.

I have strong hopes that such an ice-sheet is at present actively at work within the Antarctic area. I have a vivid recollection of reading Sir James Clark Ross's description * of a wall of ice which formed an impassable barrier 450 miles long from east to west, and which rose 200 feet above sea-level. At least 1000 feet of it being below sea-level, there would be 1200 feet of a solid front of ice. That is radically different from the paltry glaciers of 50 or 100 feet deep, found in the Northern hemisphere, and as such an immense wall is continually subjected to the denuding action of rain and moist sea-air, we might expect to find that a few miles back from its face it attained a depth of 2000 feet or more. It is extremely probable that this great body of ice extends several hundred miles inland over level country, having originated in some basin such as the Baltic.

It may be beyond the possibility of proof, but I have a great belief that real Boulder-clay is presently being manufactured at the great ice-field described by Captain Ross. The account of his voyage while in contact with the ice is most interesting, and in some points highly significant. He took soundings frequently, and found the bottom at a remarkably uniform depth of 260 to 280

* "A Narrative of a Voyage of Discovery and Research in the Southern and Antarctic Regions from 1839 to 1843," 1847.

Digitized by Google

fathoms, but he was afraid to sail close up to the ice-wall, his usual distance from it being 10 to 20 miles. He remarks particularly on the absence of bergs, as for a stretch of 160 miles he saw none at all, and then came on several very large ones, all firmly fixed to the bottom. These were at a considerable distance from the ice-wall, which was only just visible from their position. Soundings gave the usual 280 fathoms on their south side, but only about 180 fathoms on their north or open-sea side. Captain Ross speaks frequently of the wide extent and uniform depth of the great bank he had discovered, but he does not seem to have suspected there could be any connection between the broad level terrace, or bank as he calls it, and the ice-wall which overshadowed it, or that there might be some relationship of cause and effect. He estimated the depth of the ice-wall above and below the water, and determined the depth of water over the bank in front of the ice, but the remarkable fact that the estimated depth of the ice below water-level and the depth of water on the bank coincided, does not appear to have suggested to him that the whole extent of the level bank he was sailing over was actually the floor of the ice-field which the 2000 feet of ice had rolled and levelled. There seems to be no room for doubt that such is the case, and that those bergs, which he found fixed to the bottom a long way out from the ice-wall, had probably at some comparatively recent time formed the front or head of the ice-field when a succession of severe seasons had enlarged it to nearly its fullest extent. Captain Ross mentions that the most violent action of the sea seemed to be crushed and subdued by contact with the great ice-wall, but still the destructive effect on the ice itself must be very rapid, and probably much more so than on detached bergs, round which the waves could play freely. "The great barrier of ice," as he calls it, can hardly form or give off floating icebergs in the ordinary sense. Apparently it rests with its whole weight on the bottom, and although a section becomes detached, like the isolated bergs, it could not float away.

While taking soundings all along the front of the "barrier," the lead constantly brought up what Capt. Ross calls "green mud," but in other places only sand and pebbles were found. Our own blue Boulder-clay tells us that it is largely composed of black shales and coaly matter; the white Boulder-clay reveals the fact

Digitized by Google

that it has come from a fireclay region; while in a red sandstone district the colour of the Boulder-clay is as red as the sandstone itself. Doubtless, therefore, the "green mud" could tell us a good deal about the geological formation of the locality from whence it was derived.

Much valuable and exceedingly interesting information might be obtained by going over Capt. Ross's work even at this distance of time from his voyage, and plotting the actual position of "the great barrier," to show whether it has advanced or receded since 1842. Although a true ice-sheet can as a whole have hardly any true and persistent motion in any particular direction, yet an extensive snowfall towards one side of its area would cause it to move bodily towards the opposite side, and *vice versa*, so that any movement would be of an oscillating character. The yearly accumulations of snow over the whole ice-field would give rise to a lateral growth, which would be uniform all round, if its borders were all of uniform elevation. But doubtless it is to some extent bordered by rising ground, towards which the ice could not advance, so that its apparent lateral advance over low-lying districts would be more considerable, and, where it had the chance of advancing over the downward slope of the bed of the ocean, its progress would be distinctly accelerated.

The interesting question as to whether the ice-field is advancing outwards into the ocean at the present time might be determined with tolerable accuracy by taking soundings close to the barrier. If less than the usual depth over the bank was found close to the ice it might safely be assumed that the ice-field is growing and pushing a moraine before it as it advances. On the other hand, if soundings of the usual depth of 260 to 280 fathoms were found, it might safely be inferred that it is not advancing, but is perhaps actually shrinking.

It has always seemed to me a most interesting and remarkable circumstance, that, in the latitudes sailed over by Capt. Ross, open water should be found quite 10 degrees farther south than in any other section of the Antarctic regions, and extending to about 40 degrees of longitude; but I do not know of any feasible explanation. The configuration and distribution of the land might readily be suggested, and also ocean currents, but if either of these have exercised a softening influence on the climate of that particular

Digitized by Google

region the facts have still to be noted and explained. Some of our early school-books taught us that currents of heated air rose from equatorial regions, and flowed at high levels towards the Poles. I do not recollect that the subject was exhausted by explaining where the heated air struck the Polar regions, but in this connection a more practical application might be possible.

A matter which has greatly interested me is the possible influence of the Magnetic Poles on air-currents. You may have heard of the "Chinook Wind"—a marvellous, beneficent phenomenon—which renders winter in the high latitudes of Western Canada not only endurable but enjoyable. It is not a wind in the ordinary sense; it does not tear across the country uprooting trees and overturning shanties; in fact, it is hardly correct to call it a wind at all. It comes from no particular direction, but when it does arrive the snow disappears infinitely quicker than in any thaw. It seems to be so dry that it absorbs the snow. Its influence is felt from British Columbia to Lancaster Sound, but more regularly and with fuller effect in the valleys of the North and South Saskatchewan than elsewhere. It is difficult to imagine it can be anything else than an equatorial air-current. That it happens to be directed to that part of the globe, and is at the same time altogether unknown in the same latitudes in Siberia, suggests some possible connection between it and the Magnetic Pole, which forms roughly a centre-point within the area benefited by the "Chinook Wind."

We should, of course, naturally expect that if there is any connection between the Magnetic Poles and equatorial or other currents of air, the same conditions as these would prevail on the Southern hemisphere, and it would be very interesting to find that similar conditions really do exist there. It is curious enough,—you may observe it noted on any chart—that explorers have been able to make their way to very much higher latitudes in the immediate neighbourhood of the South Magnetic Pole than at any other point in the whole circuit of the Antarctic. I have thought it even possible that a large area near the South Pole may be generally free of snow and ice. It must be at such a distance from the ocean that all snow driven by storms into it will remain dry and loose, and ready to be blown back again by storms from

Digitized by Google

the opposite direction. If a southern "Chinook Wind" does really prevail, it would greatly assist in keeping the area under its influence clear of snow.

The whole question is excessively interesting, but its solution will, I fear, be even more difficult than that of the formation and deposition of the Boulder-clay.

Digitized by Google

No. XVII.—The Physical Geography and Geology of Egypt. By Matthew Blair.

[Read 29th May, 1902.]

Undoubtedly the interest of Egypt is mainly archæological. We find there evidences of a high civilisation reaching back to a remote antiquity, and of skill in building construction which no other nation has ever surpassed. But these results have sprung from causes. Man is largely governed by his environment, and hence the matter takes a geological aspect, and the question arises, were there any physical causes which could account for, or in any way explain, the advanced civilisation which at so remote a period existed in the Nile Valley? I think there were such reasons, and from this point of view I propose to discuss the subject.

The whole circumstances and conditions of Egypt are exceptional. No other country presents so many peculiar features, and such odd and unexpected elements, which render it quite unlike any other in the world. Looking first at the geographical position, we observe that it lies at the junction of three continents—Europe, Asia, and Africa,—being unique in this relationship to vast masses of land, and influences from all these would converge on Egypt. Their arts, commerce, civilisation, and mental and moral waves all passed over and through this favoured spot. Had there been only land communication, progress would have been slow, but there were waterways far into the heart of each of these continents.

Northwards the Ægean Sea washes the shores of many lands rich in historic associations, mention of which fires the imagination and delights the memory. Palestine, "over whose acres walked those blessed feet, which eighteen hundred years ago were nailed, for our advantage, on the bitter Cross"; the Isles of Greece, lying in sapphire seas, and presenting the beautiful irregular contours into which the surfaces of all limestone countries weather; "Sunnium's marbled steep," and "sea-born Salamis," and the solitary rock, where "he who lone in Patmos banished" saw apocalyptic visions; and so by the Black Sea and the rivers

Digitized by Google

Danube and Don, it was possible to penetrate far into the heart of Europe.

Eastwards the Red Sea, still the highway, as in all time, connecting the West with the romantic Orient, where Solomon procured his silver, ivory, apes, and peacocks, and where we are face to face, not only with barbaric pearl and gold, but with hoary civilisations and ancient religious systems, elaborated ages before Europe was inhabited by people higher in the scale than naked savages.

Southwards, more extraordinary still, for hundreds, even thousands, of miles, the mysterious Nile leads into regions vast and savage, peopled by strange races, whereof Othello says:—"wherein are antres vast and deserts idle, rough quarries, rocks and hills whose heads touch heaven, and cannibals that each other eat, and men whose heads do grow beneath their shoulders."

Westwards, by that azure sea which bounds the margins of the lands of many mighty nations, till it opens by the Pillars of Hercules into the wider expanses of the Atlantic Ocean.

Herodotus, who wrote 500 B.C., tells us that long before his time Egyptian sailors had circumnavigated the African continent, and we can therefore well believe that a country, situated as Egypt was, would receive in these early days streams of traffic and other influences conducing to the high culture and the great wealth which we know prevailed in it long before the dawn of written history. "Antiquity appears to have begun long after this primeval race was run."

Prosperity has usually been the lot of those nations which held the eastern and the western trade. Venice rose and flourished on this traffic, till the Portuguese found a way to the East round the Cape of Good Hope. The Portuguese in their turn were ousted by the Spaniards, who afterwards were mastered by the Dutch, and since that time the British took and have held the lion's share of the trade against all comers. Egypt seems to have been the Britain of those old days, more than 7000 years ago.

A bird's-eye view of Egypt would show us a shape more uncommon than that of any other country. Imagine a spade with a very long handle, or, better still, a boy's kite with a very long tail: that is Egypt. The delta is a triangle of about 150 miles along each side, and from it a long strip runs southwards for more than a thousand miles, varying in breadth from a few

Digitized by Google

yards to 15 miles. That is all the habitable land. It is an odd shape, and seems to enclose the minimum of land in a maximum of frontier. Its boundary marches with no civilised nation, and apparently it is a feeble land, exposed to attack on all sides, but it is not so. Outside of this slender thread of cultivation lies a sea of sand, a vast and hungry sea, heaving in small but ceaseless ripples, and ready at any moment to break in and engulf the cultivated land, but, at the same time, serving as a powerful defence against attack from without.

Just as the Dutchman has to hold a constant watch on the encroachments of the Zuider Zee, so the Egyptian has to watch the threatening torrent of sand before which he stands in constant jeopardy. There is something very impressive to a traveller who climbs the escarpment of about 800 feet, which bounds the trench which the Nile has excavated, and looks out on this dreary desert, stretching away for many hundreds of miles, treeless, pathless, waterless. He feels inclined to say with Jacob, "how dreadful is this place," or, as Coleridge puts it, "so lonely 'twas that God Himself scarce seemed there to be." There are no signs of life, yet there is movement on the sand. Every breeze raises a ripple which travels along, the fine grains being blown over the crests and deposited in the hollows, while every stone or desert bush exhibits a crag-and-tail arrangement in the most orderly manner. Against this encroaching sea of sand the Egyptian has only one defence—the river Nile—on the annual rise of which the very existence of his country depends.

The Nile acts like no other river in the world. We expect a river to be small in the upper reaches, and to increase in volume as it nears the sea, but it is the reverse of this. It is largest in the upper regions; it receives no tributary for a thousand miles, loses water as it goes along by evaporation and infiltration, and if its course were only prolonged a little more, the stream would disappear altogether into the sand.

Again, we expect a river to be in flood in the winter time, and to dry up or be reduced in volume in the summer, but this is not the case with the Nile. It begins to rise in June, is in full flood in mid-summer, and at its lowest in the winter months. This peculiarity would be fatal to any country situated 10 or 20 degrees further north, but, as it is, it suits exactly for the climate

Digitized by Google

of Egypt, where the crops grow best in the early spring. If any geological or climatic change were to alter the balance and reduce the power or extent of the Nile, the sea of sand would quickly engulf the land and blot out inhabited Egypt for ever. At present the sand remains stationary, but it has not always been so, and it is known to have encroached even in the human period.

Clear evidence of this is shown in the neighbourhood of the Pyramids, near Cairo. Not only tombs have been excavated from under the sand, but temples have been opened up, notably the Temple of the Sphinx, which had been covered over with 30 or 40 feet of sand. Even the Sphinx itself would be engulfed up to the eyes very quickly, were not care taken to keep back the ever-encroaching flood. Between the paws of the Sphinx there is an altar, and some evidences of a path, lined with smaller Sphinxes, leading up to it. At present this altar can only be reached by going down into a deep excavation in the soft and yielding sand. We cannot doubt that there is a submerged Egypt still waiting for the explorer with his shovel, to reveal many a buried treasure of antiquity.

At present Egypt for a thousand miles is practically a rainless region, dependent wholly upon the Nile, but it is evident that this has not been always so, and that the present condition is, geologically speaking, quite modern. The numerous valleys or waddies converging on the river have all the appearance of having been excavated by torrential rains. Indeed it is difficult to understand how such valleys could have been formed at all, except by running water. The gravels which lie under the soft alluvium of the delta tell of such a time, but it must have been long before recorded history.

The physical conditions quite account for the high civilisation, the profound learning, and the great skill in construction, which the ancient Egyptians showed. The Nile was their schoolmaster, the necessity of controlling its course, and utilising its water, taught them engineering and land-surveying, and trained them in that united action for the public safety out of which good government grows. No doubt astronomy also rose amongst them by their observance of the seasons when the all-valuable Nile should rise and fall.

Cheap transit is an essential element in the prosperity of a

Digitized by Google

country, and this is why the Dutch canals, when there were practically no roads in Europe, led to the prosperity of the Netherlands, and why the railway system made possible the marvellous progress of the United States. So it was in ancient Egypt; the Nile gave easy transit to all parts of the country, and was a primary factor in its progress. What Egypt always wanted, and often did not get from its various rulers, was water and good government. Happily it is getting them now, and there is at present no more prosperous country in the world than the Nile valley.

The geology of Egypt is comparatively simple. There are but three classes of rock, which cross the Nile in broad bands, roughly speaking, from south-east to north-west. They have all a very gentle dip to the north, so that as you go up the Nile you get on to the older beds. The rock around Cairo and for 500 miles up the Nile is the nummulitic limestone, part of the bed of the Tertiary sea which covered the Mediterranean basin, and extended into Persia. The upper part of it is soft and friable, and full of fossils, mostly nummulites, which are like penny pieces, hence the name. The Arabs say they are the coins with which Pharaoh paid his labourers, since petrified; and a starfish, *Clypeaster Egypticus*, also present, is called by the natives the bread upon which Pharaoh fed his servants. Deeper down the limestone is very compact and of fine grain, showing, I think, that it is built up of a very fine ooze, which was deposited in deep water far from land. The modern Egyptians quarry the stone from the surface, where it is poor and friable, but the ancient Egyptians tunnelled into the heart of the mountain, and extracted the fine unweathered material.

In the Turra hills, between Cairo and Helouan, there are extensive caves where the ancient Egyptians excavated the rock to obtain stones for the Pyramids, which are on the other side of the Nile. These were ferried across during the time of high Nile, and the causeways, up which they were dragged to the escarpment on which the Pyramids are built, are yet to be seen. Many of these stones are 15 feet long, and few are less than 3 feet in thickness.

This rock, as indeed are all the Egyptian rocks, is remarkably free from flaws, hitches, faults, or joints, so that perfect blocks of

Digitized by Google

almost any size could be quarried out of it. This limestone was never used for the obelisks, and rarely for the colossal statues, these being reserved for the Assouan granite. Only one colossal statue of it, which lies at Sakkara, is known; but for the smaller statues and for carved slabs it was much employed, and in the tombs at Sakkara and in the temple of Queen Hatasoo at Thebes there are panels of it, very finely sculptured in low relief, and in wonderful preservation.

The paucity of remains of buildings in the Delta, except than those of Assouan granite, may be accounted for by the presence of so much limestone and marble, which would be more readily destroyed and worked up than the harder rocks. Of Heliopolis, for instance, the great Temple of On, where Joseph's father-in-law was high priest, only one granite obelisk remains, and at Alexandria the column called Pompey's Pillar alone survives to mark the site of the great Serapium, or pagan school of learning, where Hypatia taught.

Over the nummulitic limestone there have evidently been other beds, now denuded away, with trunks of trees and fragments of silicified wood, which are so abundant in some places as to be called petrified forests. None of these are upright, but are lying in broken pieces on the sand, and so they possibly have been transported. The species have not yet been determined.

Numbers of small flints are also strewed on the sand, but of their origin, though they have been mentioned by various writers, no explanation has been offered. They are so numerous as possibly to indicate that they are natural flakes, and, like the trees, relics of a formation now denuded away.

Five hundred miles south of Cairo we come upon the Nubian sandstone, which is a yellow rock, rather coarse in grain, and does not, so far as I am aware, contain any fossils. It is stratified in broad alternate hard and soft bands, and the natives have taken advantage of this to scoop out rock-tombs from the soft layers, the harder ones serving for the roofs. This rock is not distorted or faulted in any way, so although not adapted for making obelisks or colossal statues, it serves admirably for the vast slabs and lintels which are seen in the Temples of Luxor and Karnak. Indeed this facility of getting large slabs to cross from pillar to pillar seems to be one reason

Digitized by Google

why the ancient Egyptians never discovered the principle of the arch, there being no indication of it in any of the Egyptian ruins; but there are slabs of Nubian sandstone which bridge spans of 24 and even 30 feet.

Higher up the river, at Assouan, we come upon the first Nile cataract, which is caused by the rock crossing the bed of the river. This is the well-known syenite, a reddish and sometimes black rock, the former variety very coarse and the latter finer in grain, the junction between the two being very sharp and well-marked. The remarkable thing about this rock is the absence of cracks or faults, and blocks of any manageable size could be quarried out of it. An obelisk, half cut out and showing the holes for the wedges, which yet lies in the quarry, is 92 feet long, and, so far as a flawless block is concerned, it might have been a mile. A Colossus weighing nearly 1000 tons lies broken at Thebes. Few of these great blocks have been moved less than 200, and some even 600 miles. This syenite seems to have been used for all the obelisks and colossal statues, as well as for smaller objects. Probably the outer casing of the Great Pyramid itself was made of it, as fragments lie all around the base. Scraps of it have also been found amidst the ruins of the Palaces of the Cæsars, on the Palatine Hill at Rome, and these are doubtless fragments of spoils from conquered Egypt.

Higher up the Nile than Assouan occur the volcanic rocks of Abyssinia, which are the main source of the fertilising mud with which the great river enriches Egypt, but they are outside of the country and therefore beyond the immediate scope of the present paper.

Note.—This paper was intended as introductory to a conversational lecture, delivered on the same evening, by Mr. James Neilson (Milnbank), descriptive of his recent visit to Egypt. He went into more detail on certain points of the geology and the antiquities, and his remarks were illustrated by a large number of photographs taken by himself, which were shown on the screen by the oxyhydrogen lantern. (A summary will be found later in this part.)—M. B.

Digitized by Google

No. XVIII.—The Geology of Portrush.

By James S. M'Lennan, Hon. Librarian.

[Read 8th November, 1900.]

A German naturalist, Dr. Roemer, writing in 1876, calls Ireland "the Land of Giant Stags, and Giant Causeways," and therefore interesting. The remains of the Great Irish Elk can be seen in our museums, but to study the "Giant's Causeway" we must visit the Emerald Isle itself, and, taking up our abode in Portrush, make several trips by the electric railway, to inspect the many wonderful geological phenomena to be found in the district. In July last (1900) I carried out this programme, and now propose to give you a few of my observations in the following paper.

Portrush is built on a rocky ridge which runs in a northerly direction for nearly a mile, and ends in Ramorne Head, with its rugged, mural precipices. West of this is the harbour, and beyond it a level shore flanked by sand-dunes. Then the abrupt and rocky coast-line again becomes prominent, stretching as far as Port Stewart, where there is a small opening, and the trap rocks assert themselves as far as the mouth of the River Bann.

At Downhill there is an exposure of the white rocks of the Chalk, succeeded by cliffs of trap along the shore for some distance, and through a projecting part of which two tunnels have been cut for the Northern Counties Railway. Beyond this the coast-line, to the eastern shore of Lough Foyle, is very flat. The rocks which rise inland belong to the Cambrian or Silurian formation, as do also most of those of the extreme north-west.

Along the eastern shore of the Portrush ridge the rocks lie a few feet above sea-level, and here occur the Liassic beds which have made the district geologically classical. Further east they sink from view, and the "Long Strand" succeeds. It stretches for over two miles along the shore, and is flanked inland by an extensive background of sandy heights and hollows, now used for the well-known golf-course.

The "White Rocks" follow this, rising to about 100 feet, and extending along the shore for nearly half-a-mile. These are

Digitized by Google

capped by a trap overflow, forming, from its dark colour, a striking contrast to the white masses of the underlying Chalk, which disappear further east, when the trap alone is visible. A small isolated mass, rising abruptly to about 120 feet, has its whole surface covered by the ruins of Dunluce Castle, said to be amongst the most picturesque in Ireland, and from it very fine views of the wide coast scenery can be obtained, including "the White Strand," Portrush, "The Skerries" (a group of islands), and the high cliffs which overhang the "Giant's Causeway."

Then comes White Bay, from which the "White Rocks" extend for a considerable distance till they are succeeded by the trap. The well-known sea-stack, "Carrick-a-rede," famous for its connecting rope-bridge, is near this, and to the north may be seen the Island of Rathlin, with the white limestone appearing on its south-western shore, under the dolerite which covers it to the north.

One of the most interesting geological phenomena of the North of Ireland is the great basalt overflow, varying in thickness from 10 to more than 1000 feet, which covers nearly the whole of Antrim, half of Londonderry, and portions of Down and Armagh, or an area of from 1000 to 1200 square miles. It has been poured out over the underlying sedimentary rocks, not from one centre of emission, but from various fissures, afterwards filled up with the ejected material, so that their exact position cannot now be definitely made out.

This overflow did not all take place at one time, but in successive eruptions differing in nature and extent, as may still be distinctly seen in all the exposed beds, which show great diversities of thickness in their various layers. It must have continued at intervals through a long series of years, as in some cases the period of quiescence has been sufficient to allow the surface of the trap layer to be disintegrated by weather action, and so prepared, before the next eruption, for the growth of vegetation, of which the fossilised remains can yet be seen. These remains of plant-life, buried by the next outflow, have been changed by the combined action of pressure and heat into lignite. A bed of this mineral at Ballintoy, east of the "Causeway," from 1 foot to 4 or 5 feet thick, and very solid in its upper portion, lies close under the trap, resting on a dark carbonaceous clay-bed. In it plant-

Digitized by Google

remains are found, one of them, *M'Clintockia Lyelli*, having been formerly only known to occur in Greenland. This lignite looks like a true coal, all its woody fibre having disappeared. It was mined at one time, but took fire and continued to burn till the roof fell in, when the working was stopped. Recently, however, operations have been resumed.

On the face of the cliff which overlooks the "Causeway" another lignite bed, nearly 6 feet thick, is seen to be much mineralised, charred and altered, by a dyke which cuts through it, and has so disturbed the adjoining rocks as to cause the lignite to look much thicker than it really is.

These trap overflows were not all poured out on land, some of them being ejected under water; nor were their materials all of a uniform character. Some were probably in an incandescent state or were merely molten, but others were composed of scoriæ, ashes, mud or dust. These materials, from the manner of their deposition (whether above or below water), the thickness of their layers, and the rate, whether quick or slow, at which they had cooled, all had an influence in producing the many varieties of trap, from the solid columnar masses of the "Giant's Causeway" to the decomposed layers of the ferruginous beds of Antrim.

Although called a plateau, this extensive trap area has not a uniformly level surface. Each successive overflow must have altered the relative levels in different places, and long-continued atmospheric denudation has also affected the surface-contours. In places the trap rises to considerable elevations above sea-level, forming the summits of several hills of from 1300 to 1800 feet, and the depressions show a series of fertile inland glens.

The beds forming the trap-plateau of Ulster are said by Professor Hull to have been poured out at three different periods, the material in each instance differing from that of the others. "The lowest part," he says, "next the Chalk consists largely of amygdaloid, intermingled with fine dolerite, tabular basalt, and thin masses of red ochre. The middle region is occupied by great beds of compact basalt, columnar in some places, and by the red ochre which frequently contains a layer of iron ore. The upper portion chiefly consists of coarse crystalline basalt, often in thick tabular sheets."

A vertical section of the cliffs from sea-level to the summit

Digitized by Google

of Pleaskin Head, one of the eastern promontories of the "Causeway," shows the following succession:—first, amygdaloid, intermingled with fine dolerite and bands of red ochre, overlaid by a bed of columnar basalt from 40 to 50 feet thick which contains the first range of columns. Above this lies a bed of ochre over 24 feet thick, and then comes the second range of columnar basalt of from 50 to 60 feet. Between this and the top of the cliffs occur several bands of basalt, ochre, and dolerite, as also a bed of lignite with plant-remains of Miocene age.

These two beds of columnar basalt are very conspicuous. Rising from the sea at Port Noffer they rear themselves on the face of the cliffs, where the lower one reaches a height of 189 feet, and falling again they come down to sea-level at Portmoon, some two miles to the eastward. The western outcrop of the lower bed forms the famous "Giant's Causeway," a natural mole or jetty of about 210 yards long, 50 yards wide at its landward end, and 10 yards wide next the sea; with a height, at its greatest elevation, of about 40 feet. It is composed entirely of columnar basalt, the columns being nearly perpendicular, and forming a pavement of irregular polygons, closely fitting into one another. They are mostly six-sided, but have a range of from three to nine sides. Cross-joints occur at irregular distances in them, varying from about 1 foot to 6 feet apart, and are not flat as they have curved centres, some concave and others convex. There are also great differences in the length and diameter of the columns, the number of their faces, and the length between the joints, though in many ways there is evidently a considerable amount of regularity and similarity between them all.

> "This far-projecting, firm basaltic way
> Of clustering columns wedged in dense array;
> With skill so like, yet so surpassing art,
> With such design, so just in every part,
> That reason pauses, doubtful if it stand
> The work of mortal, or immortal hand."

The columns of the "Giant's Loom," in the cliff just east of the "Causeway," are 32 feet long, and are jointed at intervals of from 1 to 2 feet.

The area of the north-east of Ireland is traversed by basaltic dykes which pierce the different formations in every direction, but

Digitized by Google

most frequently converge towards the region of the trap-plateau. They are of various ages—Miocene, Carboniferous, and Permian—while near the base of the trap escarpment those of Tertiary age are the most abundant. They pierce the uppermost beds of the lava-flows on the north coast, and are seen along the face of the cliffs at the "Causeway."

Around Portrush the surface rock is trap, undulating in gentle heights and hollows. The soil formed by its decomposition is brown in colour, and, from the lime, soda, potash, magnesia, and iron, which it contains to a considerable extent, it is well suited for agricultural purposes. The luxuriance of the vegetation in a trap-rock district has often been noticed, and, as remarked by the late Mr. Dugald Bell, "the excellency of the dairy produce in a district may be caused by the presence of certain old volcanic lavas poured out in that region during some immeasurably remote era of the past."

Immediately beneath the trap lies a thick deposit of the Chalk, or white limestone, which is found nowhere else in the country. At one time it extended over a much wider area, but has undergone complete denudation, except where it has been overlaid by the trap. It represents the upper division of the English and Continental Chalk, but has been hardened into a very compact white limestone, ranging in thickness from 50 to over 100 feet. It occurs in imperfectly-bedded masses with a short splintery fracture, and holding nodules and irregular layers of flint. As it does not contain any fragments of the older rocks, its materials were probably deposited on the sea-bottom, far from land, much in the same way as the ooze collects at the present day on the floor of the Atlantic and Pacific Oceans.

Two miles east of Portrush a fine exposure of this indurated Chalk rises perpendicularly from the sea-shore. It has been worn by the action of the waves and the air into many fantastic shapes, and is hollowed out into numerous caverns. Its upper surface presents an uneven appearance, attributed by Lieut.-General Portlock to erosion before the basalt overflow. A remarkable V-shaped cavity in it, about 60 feet long, exposed in a quarry in the neighbourhood, is filled with spheroids of basalt, and some geologists have considered it to be the neck of a crater. Sir Archibald Geikie suggested that this funnel-shaped cavity has

Digitized by Google

been produced after the outpouring of the basalt, by the dissolving of the Chalk, the falling-in of the roof, and the weathering of the basalt into the agglomerate-like blocks with which it is now filled. I searched this interesting section for fossils, but found only a few belemnites. These are also met with in patches in some other parts of the deposit, but generally speaking organic remains are not plentiful in it.

The next member of the geological series present in the area below the Chalk is the Greensand, the upper division of which is represented by a coarse conglomerate, known to the quarrymen as the "mulatto," because it is neither a white limestone nor a red sandstone, but something intermediate between the two. There are no exposures of it in the vicinity of Portrush, but a good section, nearly 30 feet thick, may be seen at Larne.

The Lias in England occupies a district some 30 miles broad, stretching from Yorkshire to Dorsetshire, with a depth of several thousand feet, but in Ireland it is found only around the edge of the trap-plateau, and along the base of the Chalk escarpment. It is highly fossiliferous, ammonites and univalve shells being especially abundant, while some of its sections yield fish-teeth and scales plentifully. In some of the eastern coast-exposures Saurian remains have been discovered.

On the shore close to the baths at Portrush a dark, hardened-looking rock, and which has formed the subject-matter for much examination and discussion, occurs in large tabular masses from 4 to 5 feet thick. At one time this was considered to be an igneous rock, but in 1799 fossils were discovered in it, a fact much commented on by those early geologists who believed in the aqueous origin of all basalts.

In 1802 Playfair insisted "that the specimens of supposed basalt containing shells, or the impressions of shells," from this district, "were not part of the real basalt, but a stratified rock which had acquired a high degree of induration in the vicinity of the great ignited mass of whinstone." In 1816 Prof. Conybeare and Dr. Buckland strengthened this opinion, by stating they "felt convinced, while examining the spot, that the rock was no other than the clay-slate of the Lias formation in an indurated state."

In 1832 Mr. (afterwards Dr.) James Bryce of Belfast thoroughly worked out the relative positions of the igneous and metamorphic

Digitized by Google

rocks, both at Portrush and at the Skerries, and confirmed the above-quoted opinions in regard to this, now classic, rock, which represents the lowest division of the Lias. It is evident that the existing remains are those parts of the rock which were hardened by the intruded dolerite, and so were able to resist the various denuding agencies, while the softer portions, in their original state, were all cleared away. It contains ammonites and other fossils, but has been so altered that they cannot be extracted in good condition, and are hardly recognisable. A list of twenty-six different species from it was, however, given by Portlock.

Various theories have been put forward to account for the alteration of this rock into a material resembling hornstone. Some observers have thought that it may have been caused by the overlying Miocene dolerite, but this seems unlikely, as the lignite beds, a few inches below the latter, have not been in the least affected. It has also been suggested that so-called "local metamorphism" may have been the chief factor in bringing about the change, as it is well known that, in the vicinity of a centre of volcanic activity, gases and other igneous products passing through the adjoining rocks have often given them a baked appearance.

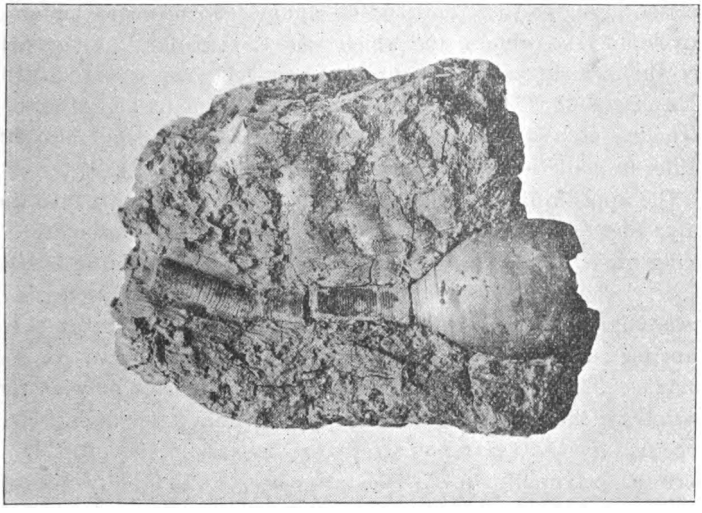
Digitized by Google

No. XIX.—Fresh Points in the Structure of Apiocrinus.

By A. L. du Toit, Geological Commission, Cape Town, S.A.

[Read 13th February, 1902.]

The object of this paper is to place before the Society—firstly, a brief description of the structure and growth of this crinoid, and secondly to point out several peculiarities exhibited by two specimens from the Andersonian Museum,* with their consequent bearing on the morphology of the organism.



Apiocrinus elegans (Defrance), from a specimen in Kelvingrove Museum.

The crinoid, *Apiocrinus*, with a geological range from the Lias to the Lower Cretaceous, is found in Britain chiefly in the Middle Jurassic; and in the Alps stems are got in great profusion. The best known species is that commonly called the "Pear Encrinite," from the Bradford Clay, a pale grey marly clay which lies between the Forest Marble and the Great Oolite, in the Middle Jurassic. This clay reaches its greatest thickness near Frome and Bradford in Wiltshire, and rapidly thins out to the north and south. The

* These specimens are now in the Kelvingrove Museum, Glasgow.

Digitized by Google

crinoid is often found in the clay with its root or pedicle attached to the top of the Great Oolite limestone—once an old sea-floor —upon which the organism grew.

It is commonly known as *A. Parkinsoni* (D'Orb.), and sometimes as *A. rotundus*, but its true name is *A. elegans* (Defrance). The column is long, smooth and cylindrical, built up of thin, flat joints, which are pierced through the centre to afford a passage for the axial canal. The surfaces of these plates or joints are finely and radially striated; they are also concentrically marked, the rings being somewhat analogous to the rings of growth seen in tree stems. The column, at its lower extremity, is surrounded by a mass of calcareous matter more or less conical in shape. In section it is seen to be built up of laminæ of calcareous material enveloping the column, and which was secreted during its growth by the crinoid—probably in the form of a viscid exudation. The origin of this was described by Parkinson in his "Organic Remains of a Former World," as early as 1811, and also by Miller in his "Natural History of the Crinoidea," 1821.

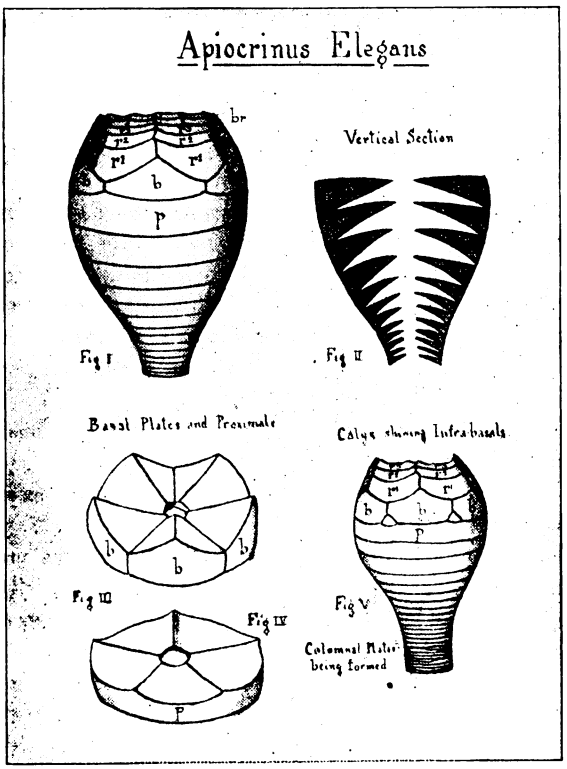
The upper columnal plates expand and pass gradually into the calyx (fig. I., see p. 189), the upper surface of the last plate, P, being provided with five radial ridges between which the basals, b, lie. These enlarged columnal joints are considerably thicker, externally, than the others, are concave below, and are, at their superior surface, more or less convex, with a perforation in the middle. They are radially striated, and in contact only at the periphery, thus enclosing a series of lenticular spaces connected together by the central apertures, as is very well shown in a vertical section (fig. II.). The last plate, P, is usually termed the "centro-dorsal," but it has been more appropriately called, by Mr. F. A. Bather, the "proximale." Upon this plate, and between the ridges on it, the wedge-shaped basals, b, rest (see fig. I.), with their lateral edges in contact (fig. III.), and forming a surface with five ridges and five depressions.

In each depression a radial plate, P_1, rests (fig. I.), covering the junction of two adjacent basals. These radial plates are excavated and radially striated on their upper surfaces, and carry directly above them plates P_2 and P_3, termed "costals," but called by Bather the first and second "primibrachs." The upper surface of P_3 is furnished with two inclined faces which

Digitized by Google

support two free brachial plates, b, r, perforated, and furnished with well-defined transverse ridges. From the ten brachials spring the ten arms which bifurcate once or twice, being formed of a single row of plates.

The interior of the calyx shows all these plates arranged so as to form a cavity, pentagonal in form, and contracting in area downwards (figs. IV. and V.).



The proximale can just be distinguished deep down with its five slight ridges and almost circular perforation. Above come the basals, forming a small pentagon; then the radials, forming a slightly larger pentagon; and above them the primibrachs and brachials—very large pentagons—forming a rim or edge to the calyx. By far the greater portion of the interior area is occupied by the radial plates, P_1.

Digitized by Google

The course of the nerves can often be traced downwards from the arms through the primibrachs, radials, and basal plates. The calyx was roofed over by small plates, but these and the integument to which they were attached are never found in position.

Such is the structure of the normal form of the crinoid, but the two specimens which have been described show considerable variation from the standard type. The first shows small triangular plates which occur at the junction of the lateral edges of two basals with the proximale. Four of these plates are present—two being very minute—the fifth is entirely absent. The position of these plates naturally suggests them to be infra-basals, though possibly they may be incomplete columnal plates.

Firstly, however, the origin of the proximale has to be considered. Crinoids may be divided into the classes Monocyclica, showing basals, and Dicyclica, showing both basals and infra-basals (Bather). The latter class are subdivided into three orders—(1) Inadunata, (2) Flexibilia, and (3) Camarata, the Apiocrinidæ belonging to the second, the Articulata of Wachsmuth and Springer. These authorities believe that in all Flexibilia the top columnal is not the latest formed but a persistent proximale, though I have not been able to confirm their views.

This specimen shows two small wedge-shaped columnal plates being formed between the columnal stems at the base of the calyx. In this way the stem was lengthened by the insertion of new plates far below the proximale itself.

Wachsmuth and Springer, however, believe that the proximale has been formed by the fusion of the top columnal with small infra-basals; the five ridges on the upper surface representing the traces of the latter plates. This view has been followed by Zittel, Carpenter, Nicholson, and others, and very generally accepted.

The presence of these ridges affords no evidence on this point, for similar ones often occur on the surfaces of the lower columnal joints, as is shown by a specimen now exhibited. The small plates shown in the figure prove that though infra-basals are present they do not take the place of these ridges, for the latter can be distinctly made out in the interior of the calyx. Such plates were noticed by Parkinson as early as 1806, and were stated by him to be large and "well defined." The study of the

Digitized by Google

allied crinoid *Millericrinus* shows that minute infra-basals occur occasionally, but they are confined entirely to the interior of the calyx. In the specimen shown at least one of these plates passes right through into the interior and fills up the space usually occurring between the lateral edges of the basals.

A second specimen proves this entirely. Here we have at least two infra-basals occurring between the basals and the proximale, and resting directly on the ridges of the latter, showing that the proximale is certainly not derived from any fusion of plates, but is only a modified columnal. The exterior of the specimen is very indefinite, but so far as can be made out the infra-basals do not appear on the surface. This is not of any importance, for they might cease to grow, and therefore be covered up completely by the basals. We may then conclude that they have been lost by atrophy, and not by fusion, as is generally believed.

The occurrence of the inter-basals may not be uncommon, but, as the interior of the calyx is often filled up, their presence may escape notice. It is also interesting as affording another link between the undoubted monocyclic and dicyclic crinoids, *Apiocrinus* having for some time been placed in the small group of the Pseudo-monocyclica, but only lately removed to the Dicyclica (by Bather in Lankester's "Treatise on Zoology").

The monocyclic forms (*i.e.*, those without infra-basals), are thus derived from the earlier (palæozoic) Dicyclica, a descent now generally favoured by most authorities; and the ancestors of *Apiocrinus* and *Millericrinus* were furnished with infra-basals. The still later crinoid, *Bourgueticrinus* (called *Apiocrinus ellipticus* by Miller) from the Chalk, much resembles *Apiocrinus*, but is undoubtedly monocyclic.

In conclusion, I have to acknowledge my indebtedness to the University Library for the use of books, and to Mr. Fingland for the photographic plates from which the figures in this paper have been reproduced.

Digitized by Google

No. XX.—On a Volcanic Series associated with the Schists of North Glen Sannox, Arran. By the late William Gunn, F.G.S., of H.M. Geological Survey.*

[Read 11th June, 1902.]

This paper is intended as a supplement to the one "On the Old Volcanic Rocks of the Island of Arran" which I read before the Society in May, 1899, and which was afterwards printed in the *Transactions*, vol. xi., p. 174. A note appended to it announced the discovery in 1899 of an old set of volcanic rocks intercalated with the schists of North Glen Sannox. These old lavas are associated as at Ballantrae in Ayrshire with cherts and dark shales, and it is not improbable that, like them, they are of Arenig age.

In North Glen Sannox the whole series appears to be regularly and conformably intercalated with a portion of the Highland schists. They occupy a strip of country which crosses the glen in a north and south direction. This strip is between 1 and 1¾ of a mile in length, with a breadth varying from 100 to 400 yards. At its lowest point in North Sannox Burn it is about 120 feet above the level of the sea, from which it is distant rather more than a mile. It rises on the north side of the Glen to about 900 feet near Corloch Crags, and on the south side it reaches 944 feet in the hills called Cnocan Donna. The rocks composing this area all appear to have a high dip in the general direction of E.S.E. Sometimes they are vertical, but there is much folding in places; especially in the bands of black shale or schists.

At their southern extremity these rocks are cut off by the intrusion of the granite at the north-east end of Suidhe Fheargus, while at their northern extremity a fault brings down against them Lower Carboniferous rocks. They apparently overlie a thick series of schistose grits which are well exposed in the North Sannox Burn at the bridge; and they dip under another set of

* To the lasting regret of all his friends the author, after a period of failing health, died on 22nd October, 1902, long before this paper was in type. The proofs have, however, been read by his colleague Mr. (now Dr.) Peach, of the Geological Survey, who having accompanied him over the ground was personally acquainted with the author's views. [Ed. *Trans.*, 1904.]

Digitized by Google

schistose grits, which, however, can only be studied on the south side of the Glen, as they are cut out on the north side by the Highland Fault which brings down the Lower Old Red Sandstone against the volcanic series.

The general succession of these rocks appears to be as follows, in descending order:—

7. Coarse schistose grits, smooth weathering.

6. Thin bands of slaty schist, apparently alternating in places with thin bands of trap and traces of dark schist.

5. Upper trap-bed, greenish grey in colour, fine grained, and in places schistose, with lenticular bands of agglomerate.

4. Bands of light-coloured and dark chert with much laminated dark schist, and a band of schistose grit.

3. Lower trap-bed, often massive, sometimes containing bands of agglomerate, *e.g.*, on the north side of the glen.

2. Bands of black schists, associated occasionally with chert and some slaty schist.

1. Thick mass of strong schistose grit, some greenish.

The whole succession may be observed in the North Sannox Burn and on the hillside to the southward. On the north side of the valley the upper trap and the grit series are at first almost entirely concealed by glacial drift, and eventually are cut off by the Highland Fault. The North Sannox Burn gives the whole succession, but not a complete section of the beds from No. 5 upwards, which are only visible in places.

There is a good exposure of the coarse schistose grits (No. 1) about the bridge where the road to Loch Ranza crosses. About 70 yards east of the bridge there is a band of finer-grained schist, and some 80 yards further we come upon a brecciated rock—the like of which is met with in several places. It appears composed mainly of trap fragments, but is not exactly similar to a true volcanic agglomerate, and may have been formed by the brecciation of the molten rock in motion before its final consolidation. Above this comes the lower bed of trap (No. 3) which occupies the stream for 100 yards. It is for the most part a massive and rather fine-grained rock, greenish or greenish-grey in colour, with prominent "pillow" structure, identical in character with that described and figured in the Survey Memoir on the Southern Uplands by Messrs. Peach and Horne. My colleague, Mr. [now Dr.] Peach, who

Digitized by Google

accompanied me one day over the ground, recognised the resemblance at once. The chilled and rounded margins of these "pillows," and the numerous amygdules a little way in from the surface, are very conspicuous when closely examined.

At the foot of the small burn called Allt Dornach, which joins the main stream on the north, we find the dark schist (No. 4) which overlies the lower trap. It seems much contorted in places, and is accompanied by a breccia similar to that previously described. The dark schists are accompanied by cherts, which, however, are not well exposed at this place, though there is a good section of them with the dark schists about 200 yards up the next small stream to the north, called Allt Carn Bhain. Some of the cherts are dark in colour, but the thickest bands seem generally to be light-coloured or grey. The burn last mentioned runs nearly along the strike of these beds, and exposes in many places fairly good sections of them. The same dark schist band is exposed on the south side of the main valley, where it is accompanied by a gritty band lying just beneath the upper trap-bed. This gritty band and the lower part of the upper trap-bed are not exposed in the main stream, there being a gap in the section.

The upper trap (No. 5) is, in the main, a massive and medium, or fine-grained, greenish rock, much like the lower bed, but the upper part of it in places is so schistose as to much resemble the so-called "green beds." There is a good exposure of the whole of this bed about the two hills called Cnocan Donna, where the series attains its highest points above the sea, and in each of the knolls there is a band of coarse agglomerate intercalated with the traps. These bands are lenticular, and are made up of angular fragments of fine-grained trap. Neither of the bands can be traced for more than 40 or 50 yards, and the more southerly of the two is but 5 or 6 feet broad at the most. The other is larger, and may be as much as 30 feet across at its widest part. These bands are probably true volcanic agglomerates running along the strike. On the south side of North Sannox Burn near the upper margin of this trap, and also in a small burn to the south, there is a peculiar band of mottled rock, greenish grey and red. A little east from this we come upon the finer schistose band which overlies the trap, and this is also visible in a small burn on the south side of the valley.

Digitized by Google

The upper schistose grits (No. 7) are poorly exposed in the main stream, but they are a prominent feature on the hillside, 300 yards to the southward, and they can be followed along the strike for a considerable distance.

There are many exposures of the lower trap-bed on the hillsides, both north and south of the main stream. On the north side it is very prominent in the crags of Corloch, and it forms all the crags called Torr na Lair Brice on that side. On the south side there is a specially prominent crag of it about 300 yards S.S.E. of the bridge.

In addition to the rocks above described there are others which are probably intrusive. One of these occurs about 600 yards from the main stream, and near Allt Dornach, and was the first undoubtedly igneous rock to be noticed in this area. It is a rather coarse-grained rock, now much altered, but it was in all probability originally a hornblende gabbro. A somewhat similar rock, but still more highly altered, occurs in Allt Carn Bhain, about 200 yards from the foot of the burn, and near the best exposure of the cherts. The two lava-beds or trap-beds described are altered basic igneous rocks, varieties of epidiorites. Sometimes the rocks are scoriaceous, and the cavities have been filled in with calcite.

The cherts are granulitised to a great extent, and no traces of radiolaria have been found in them. The black schists were diligently searched in several localities, but no traces of organisms of any kind have yet been found. It is, therefore, unwise, perhaps, to dwell too much on the undoubted resemblance between this volcanic series and its associated beds with the Arenig rocks of Ayrshire at Ballantrae. All that we can say is that the rocks in the two localities are *probably* contemporaneous.

Strips of rocks of a somewhat similar character, and probably of the same age, have been found by my colleagues of the Survey, Messrs. Barrow, Clough, and Dakyns, at various places along the Highland border, from Dumbartonshire to Kincardineshire, but nowhere except in Arran do these rocks appear to be intercalated in the Highland schists.

Digitized by Google

No. XXI.—A Tertiary Volcanic Vent in the Island of Arran. By James Stark, V.P.

[Read 11th December, 1902.]

The red sandstone rocks of Arran have long afforded food for reflection and discussion to geologists, and many and various have been the opinions expressed regarding them. It is now generally understood, however, that the great bulk of them south of Brodick are of post-Carboniferous age, and that north of that village they lie unconformably on greatly older, though lithologically not very dissimilar strata; the line of junction passing across the island, nearly along the line of the String Road, to the mouth of the Machrie Water. So slight is the unconformity that it is hardly recognisable at any one locality, yet the newer rocks rest on lower and lower horizons of the Carboniferous series towards the west, until at Machrie Waterfoot they overlap them altogether, and lie directly on the Old Red Sandstone.

As most of our members are aware, a very remarkable discovery was made in 1899 by the late Mr. William Gunn, F.G.S. [see Mr. Gunn's own account, *antea*, page 192], which has furnished conclusive evidence as to the age, not only of the red sandstones, but also of the intrusive igneous rocks of the south of Arran. A very intricate complex has long been known to exist south of the String Road, covering an area of 8 to 10 square miles, and including a group of hills ranging up to 1700 feet over sea-level. The recent detailed survey of this complex has proved it to be a plug or core which fills an ancient volcanic vent, from 3 to 3½ miles in diameter. This core consists of a great variety of fragmental materials, penetrated by numerous igneous intrusions ranging in composition from granites to rocks of extreme basic type. To describe a recent visit to this interesting part of Arran is the object of the present paper.

Passing from Brodick up Glèncloy the same red sandstones and quartz-breccias, with the same southerly dip, as are so well exposed along the Corriegills shore, are seen in the bed of the Cloy Burn. Carved, as it is, out of the soft red sandstones, Glencloy is a

Digitized by Google

comparatively wide valley, with gently sloping sides. This character, however, is entirely changed at its head, where it branches into Glendhu and Glen Ormidale, both dark, narrow ravines, flanked by precipitous walls of nearly naked rock.

The bottom of Glendhu is encumbered with a grand series of moraines, marking the successive terminations of the last retreating glacier which once occupied the glen. On one of the outermost of these, a heap of rude stones marks the site of an ancient fort, which, though marked on the map "Bruce's Castle," is undoubtedly prehistoric. As in other parts of Scotland the name of Wallace is sometimes associated with places which he probably never saw, the same liberty has doubtless been taken in Arran with the name of Bruce.

The innermost moraine in Glendhu approaches 100 feet in height, and is probably one of the finest in Scotland. It crosses the glen from side to side and presents a concave curve, with a steep sloping escarpment, like a railway embankment, towards the head of the glen. This moraine has evidently "ponded" back the drainage of the glen for a prolonged period, forming a lake, till, in the process of time, the overflow has breached the barrier and drained off the water. The flat, marshy bottom of the ancient lake now forms a favourite and secluded feeding-ground for the red deer.

Scattered over the surface of the moraines are numerous rock-fragments, some of huge dimensions, which have rolled down from the corrie forming the head of the glen. These consist, for the most part, of intensely hard quartzite, or of volcanic agglomerate, often of both firmly fused together in the same block. This quartzite is simply the local red sandstone indurated and altered by contact with the great volcanic core, of which the agglomerate forms the eastern margin, and to the hardening effect of which the bold and rugged features of the head of the glen are due.

The ascent from the bed of the ancient lake up the corrie forming the head of Glendhu is a stiff bit of climbing work, and presents a fine section of the igneous mass which composes this part of the vent to a height of nearly 1000 feet. The rock is excessively hard, dense, and basic in character; the large prisms of hornblende, often more than an inch in length, consequently

Digitized by Google

indicate that it must have consolidated at a great depth, and must have cooled very slowly.

At a short distance north-west of this point there is a patch of granite with an area of about a quarter of a square mile, scarcely distinguishable from the fine-grained variety of the northern part of the island. It is, apparently, intrusive among the basic rocks which form this part of the vent.

Proceeding westwards, after attaining the moory table-land above the head of the glen, the rock is not often exposed, but where visible it appears to be of a dark basic character. It is, however, so greatly weathered that fresh specimens are not easily obtained. Passing on over the watershed, which at its lowest point is over 1500 feet above sea-level, the headwaters of Balmichael Burn are reached. Springs of fine clear water, rising through the spongy moss, here unite to form a brawling stream, which has cut out for itself a deep and narrow gorge, where the structure of the western side of the vent is exposed. As seen in the bed of the burn the rock generally consists of a coarse agglomerate or breccia, crammed with blocks of a great variety of materials, chiefly igneous, but with many of quartzite, and occasionally of comparatively unaltered clastic rocks. Fragments containing numerous fossils of Liassic and Cretaceous age have been discovered in this agglomerate by the Officers of the Survey, but we were not fortunate enough to find any. The bottom of the glen is so narrow and steep, and so encumbered with loose blocks, as to fully occupy one's faculties with the difficulties of getting through it, leaving, in the course of a brief visit, but little opportunity for the requisite close search for the organic remains.

A mile south of Balmichael the Clachan Glen also debouches on the Vale of Shiskin, the two burns uniting to form the Blackwater. For more than a mile above the Clachan Bridge the rocks exposed in the bed of the burn are the same red sandstones as on the east side of the island, lying nearly in their original horizontal position. Numerous intrusive sheets and dykes, mostly of felsitic character, penetrate the sandstones, and seem to indicate that the focus of volcanic disturbance is in the immediate neighbourhood. This glen, indeed, may be taken as defining the southern boundary of the vent.

Compared with the narrow gorge cut by the Balmichael Burn,

Digitized by Google

the Clachan Glen is wide and open, and evidently dates far back into Pliocene times. During the glacial period the old valley has been choked up with Boulder-clay, of which only a small portion has since been removed by the post-glacial burn. About a mile above the bridge, the burn, in its process of re-excavating the glen, has strayed for some distance beyond the left bank of the pre-glacial valley, and has cut a deep and narrow cañon through a sheet of diabase, which here overlies the red sandstones; while the subsequent waste of the Boulder-clay has since almost made an island of the portion thus cut off.

The bottom of the Clachan Glen is greatly encumbered with large boulders, which have been washed out of the clay, and vast numbers of these have been carried by winter spates far beyond the mouth of the glen, into the level plain of Shiskin. To secure this fertile piece of land from inundation, embankments about 30 feet apart have been carried along the sides of the stream, and the space between has become gradually filled up with boulders, so that the channel has been raised in some places quite 4 feet above the level of the fields. This river of boulders, which vary from a few inches to a couple of feet in diameter, extends in a straight line for a mile from the mouth of the glen, and, viewed from above, is seen to form a series of long, low ridges, like immensely elongated ripple-marks. The danger of the adjoining low-lying fields being flooded through the breaching of the embankments is evidently realised to be a serious one, as elaborate works are now being carried out to strengthen and heighten them.

Returning now to the more immediate subject of the present paper, probably the best section to illustrate the structure of the volcanic vent occurs about a mile north of Balmichael Glen, in the bed of the Allt-an-Dreish, a small tributary of the Machrie Water. At this point the western edge of the vent almost coincides with the Shiskin Road, close to which a quarry for road-metal has been opened in a boss of fine-grained granite. Following up the burn from the road bridge, the granite is exposed for some 500 yards, where we reach a fine section deeply cut by the stream into a series of fresh and unaltered strata lying in a nearly horizontal position. In ascending order the series commences with a bed of red marl, the bottom of which is not visible; above this comes a thick series of gray marly shales, followed by black

Digitized by Google

shales with thin bands of dark limestone, which abut abruptly against a wall-like mass of quartz-porphyry. These rocks are exposed along the burn for some 200 yards, and are also visible to a lesser extent in another branch of the same burn 100 yards to the north, so that they appear to cover an area of some acres, while their thickness probably approaches 100 feet. They are nevertheless merely a huge fragmentary mass, fallen from above into the vent, the age of which must, of course, be later than that of the fragments enclosed within it.

Marine shells from the black shales and limestones (specimens of which are exhibited) have been recognised as of Rhaetic or Lower Liassic age by the Officers of the Survey; who, as already stated, have collected quite an extensive series of fossils from rock-fragments embedded in various parts of the vent. Amongst these are white silicious limestones containing Cretaceous foraminifera, and identical with the limestones of Antrim.

The first explosions of this great volcano have therefore been proved to be of later date than the Chalk, and that formation, with the underlying Jurassic and Rhaetic rocks, must once have covered extensive areas in the West of Scotland, and were probably continuous with the similar strata which now exist under the basaltic plateau of the North of Ireland. It may also be accepted that the great bulk of the intrusive granites, porphyries, felsites, and basalts of Arran belong to the one phase of volcanic activity which in Tertiary times extended from the North of Ireland probably as far as Iceland.

The great variety in the character of the igneous intrusions of the Arran vent indicates that this volcanic phase included very many separate eruptions, which doubtless extended over a very prolonged period. This is also indicated by the huge piles of bedded lavas, sometimes over 3000 feet in thickness, which have been poured out by other great volcanoes of corresponding age over many hundreds of square miles west of the existing mainland of Scotland. Of these lavas mere fragments are now left to tell the tale in Staffa, Mull, Rum, Skye, and elsewhere throughout the Inner Hebrides, as also in St. Kilda and the Faröe Islands.

After the recent volcanic eruptions in the Island of Martinique, a telegraph steamer reported that in grappling for a broken submarine cable it was found that the floor of the sea in the neighbourhood of the volcano had subsided more than 1000 feet.

Digitized by Google

The same thing, doubtless, frequently occurred during the various eruptions of the Arran volcano, as the earth's crust must, of necessity, have subsided over an area from which such an immense quantity of material had been extruded. In doing so it could hardly fail to be fractured in all directions, with the result that the pressure being thus relieved over portions of the fiery magma, these would liquefy, and the molten rock would be injected with great force into the fissures, through which it may, or may not, have reached the surface. Hence the appearance, after long denudation, of the numerous dykes which literally seam the shores of Arran.

Again, as the superincumbent crust slowly subsided over the deep-seated and shrinking magma, it is quite conceivable that its lower strata may have settled down faster than the upper portion, parting from it along a line of bedding. As soon as this parting began to take place the molten rock would be forced into the incipient fissure, under the pressure due to the column of lava in the pipe of the volcano, which must have amounted to several tons per square inch. Yielding to this enormous pressure, the fissure would be widened by the wedging of the lower strata of the crust downwards on the surface of the magma, until a sill or sheet of quite a considerable thickness had been injected between the bedding-planes of the rock. Many such sheets of felsite, pitchstone, and more basic materials, are well exposed along the Arran shores, notably the great sill of dark basic rock which forms the ridge of the Clachland Hills; and the bold escarpment extending from Dunfion to Clachlands Point.

Some geologists have disputed the theory that sills have been forcibly injected, on the ground that the weight of the superincumbent strata would generally be too great to be lifted in this manner. The suggestion that they were injected while the crust was subsiding differentially over a shrinking magma appears to get rid of that objection.

Messrs. Clough and Goodchild, of the Geological Survey, strongly advocate the theory that sills and dykes may be formed by a process of assimilation, by which the molten matter, aided by the presence of alkaline and highly superheated water, eats its way in, along the contact-surfaces of joints and bedding planes, by a process similar to metamorphism; and there seems no reason why such

Digitized by Google

an action should not take place when the conditions are favourable. This appears to have been the case at Clachlands Point, where the great basic sill alluded to is seen sending strings and tongues into a red felspathic conglomerate, which has, in consequence, been so completely metamorphosed, that it is almost impossible to differentiate it from the igneous intrusion, except by its still containing rounded pebbles of unaltered vein-quartz. Specimens on the table show the two rocks firmly fused together, and only distinguishable from each other by the pebbles enclosed in that which was once the conglomerate. The pebbles, though not altered, are so firmly fused to the matrix that they break across with it, rather than part from it.

How vast the lapse of time since the final extinction and cooling-down of these the latest of British volcanoes, during which their giant cones, some probably rivalling Etna in bulk, have entirely disappeared, their cores trenched and laid bare to the very roots, and only a few isolated fragments of their lava-flows still left!

Illustrating the transitory nature of the most durable of earthly things, our National Bard remarks that "the tooth o' Time may gnaw Tantallon." A much older and altogether unknown rhymster classes together as similar and almost impossible feats to "ding doon Tantallon," and to "big a brig to the Bass"; yet five centuries have sufficed to reduce the fortress to a time-worn ruin. From considerations of the present average rate of waste of land, as indicated by the annual amount of sediment removed and carried down by rivers, Sir A. Geikie has made an estimate that not less than twelve millions of years have elapsed since the close of the Tertiary period of volcanic activity in Scotland; while Mr. Goodchild is inclined to put it as high as sixteen millions. In either case it is a length of time which the mind fails adequately to grasp; but to borrow a scale suggested by the late Dr. Croll, let us suppose that a century be represented by one-tenth of an inch, then the age of Tantallon Castle to the present time would be represented by half an inch. On the same scale the time since the extinction of the Arran volcano would be represented by 1000 to 1300 feet. May we then state the proportion thus:—As half an inch is to 1000 or 1300 feet so is the waste on Tantallon to that of the Miocene volcanoes of Arran and the Inner Hebrides?

Digitized by Google

No. XXII.—"CAMP SILURIA." By PETER MACNAIR, Joint Hon. Secretary, Keeper of the Natural History Collections in the Glasgow Museums. With two Photographs [Plate No. VI.], and a Section.

[Read 14th March, 1901.]

AMID the recesses of one of the streams that descend from the Nutberry Hill, on the confines of Lanarkshire and Ayrshire, there might have been seen in the summers of 1899, 1900, and 1901, a tent with a flag bearing the legend "Camp Siluria," and another close by. But being some six miles distant from the great highway which bears southward to Carlisle, they were too far removed from the beaten track to leave much chance of their discovery by the ordinary pedestrian or tourist, and it is a country almost unknown to the cyclist. Hidden deep down close beside the bank of the burn, the camp would never have been noticed from the rough mountain path, had not a small tributary burn here cut a deep gash into the wall-like banks of the main stream, revealing the tents nestling under an overhanging cliff upon a broad patch of alluvial haugh-land.

In the year 1882, a well-known member of the Society, Dr. J. R. S. Hunter, of Braidwood, camped out for three months on the upper reaches of the Logan Water, his tent being pitched at the place known as Shanks Castle, with the object of collecting the Upper Silurian fossils which occur in great numbers in the shales and mudstones exposed in the numerous sections laid bare by the action of the stream and its tributaries; and then for the first time in this lonely moorland region the flag "Siluria" was unfurled. A full account of the doctor's doings here was afterwards read by him before the Society, and afterwards printed in the *Transactions*.*

Within more recent years an important discovery of fish-remains has been made in the same beds, and it was that which induced Mr. David Nimmo and the writer to adopt Dr. Hunter's plan, and again unfurl the flag "Siluria" in the Lesmahagow uplands. Had it not been for the enthusiasm shown by Mr. Nimmo the

* "Three Months' Tent Life amongst the Silurian Hills of Logan Water, Lesmahagow." *Transactions*, vol. vii., part 2, 1885, page 272.

Digitized by Google

idea would neither have been begun nor carried out to its successful issue. Behind everything he was the motive power, and those who lived in the camp, whether for a single night or for the season, owe a debt of gratitude to him for his hospitality. Nor was this welcome confined to those immediately connected with the geological operations, for in the course of time when news of the camp began to spread abroad, and farmers and shepherds from far and near came to listen to the wonderful philosophy propounded by "the daft callants that broke the chuckie-stanes," they drank their host's health in cups of tea, or occasionally in something stronger.

The history of the original discovery of this inlier of Upper Silurian rocks in the neighbourhood of Lesmahagow is already so well known that I shall only give a brief sketch of it here, showing its connection with the later ones just mentioned. A distinguished late member of the Society, Dr. Slimon of Lesmahagow, had the honour of being the first to reveal the existence of Upper Silurian rocks north of the Tweed. At the Meeting of the British Association held in Glasgow in 1855 he exhibited a collection of remarkable fossils quite new to geologists, which had been gathered in the course of his professional visits through the district. These fossils having come under the notice of Sir Roderick Murchison, he lost no time in visiting the places where they had been found, under their discoverer's leadership, and in a letter to Professor Harkness he described the important results of his visit as follows:—

"I came last night direct from the Lesmahagow country, where I passed two entire days with the good Slimon, and took Ramsay with me. We had glorious weather. I am more satisfied with my general results than anything I have seen for many a day.

"The merit of this discovery is Slimon's, and I shall raise a statue to him for it. As I had a very fast horse to take me from point to point, and used my legs up every burn (including all the Carboniferous series to the east) and to the top of Nutberry, and considerably to the west of it, I have no doubt as to the completeness of the evidence. . . .

"The Old Red is a poor affair there, one member of it, *i.e.*, the Lower, is undoubted, and great dislocations separate it from the Lower Carboniferous formation. But the graduation into Upper

Digitized by Google

Silurian on the Logan Water, and the alternation of red and grey until all becomes grey, is the best exemplification of transition that can be. In short, it is equal to any passages of the same rocks in Hereford, Salop, and Cumberland. When Salter has examined the fossils I will tell you more. In the meantime I have left Slimon the happiest man possible, and I intend, D.V., to give a little introduction to the description of the wonderful geological parish of Lesmahagow, and the merits of the poor, but meritorious Dr. Slimon, who, if he had been rich enough to visit his patients on a horse, and had not travelled up the braes on foot, would never have made this excellent hit."

In the third edition of his "Siluria," 1859, Sir Roderick Murchison gave an account of the structure of the ground, accompanied by a horizontal section, and in the Memoir to accompany sheet 23 of the Geological Survey Map there is a somewhat detailed account of the Upper Silurian inliers found in Lanarkshire and Ayrshire. One of the most interesting points in the geological structure of this area is the apparently conformable sequence from Upper Silurian into Lower Old Red rocks. This conformability has been recognised by Murchison, Ramsay, and Geikie, and subsequently by Dr. Peach.

In the Memoir and the Map of the Survey the line of demarcation between the Old Red Sandstone and the Upper Silurian rocks was drawn considerably below the horizon which the more recent palæontological discoveries would warrant, and thus the red and yellow sandstones and conglomerates, and certain green and red mudstones with bands of grey shale and greywacke, were included in the Lower Old Red Sandstone, the occurrence in these beds of organisms identical with those found in the underlying Ludlow rocks being accounted for on the supposition of the occurrence of marine or brackish-water conditions during the accumulation of the lower members of the Old Red Sandstone.

In the course of the recent revision of the above-mentioned Survey sheet (23), special attention was given to the fossiliferous bands found in the so-called passage beds, and as a result of this, in the year 1897 Messrs. Macconochie and Tait discovered a remarkable fish-fauna in a bed intercalated in the green and red mudstones which immediately underlie the thick bed of conglomerate. The consequence was that they were led to

Digitized by Google

transfer many of the beds formerly included in the Old Red Sandstone into the Upper Silurian, and they are now considered to be the equivalents of the tilestones, Downtonian sandstones, and Ledbury shales, which in Herefordshire overlie the Upper Ludlow rocks.

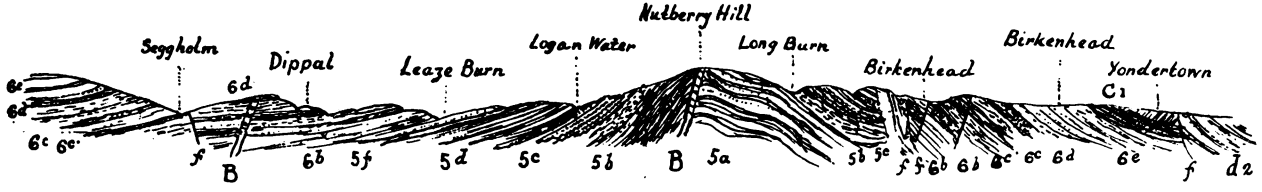
There cannot, however, be the least doubt that the merit of renewed attention having been given to the fauna of these beds is due to Mr. James Young of Lesmahagow, who, in the year 1896, discovered an entire fish of the genus *Thelodus* in the upper reaches of Logan Water, above Logan House, and in the same bed as that in which Dr. Hunter got the remains of a Scorpion (*Palæophonus*), undoubtedly of Ludlow age. Dr. Hunter also discovered in the same district, in 1882, scales of *Thelodus*, which he described as "small scales something like those of Acanthodian fishes." Specimens of these presented to the late Dr. John Young, F.G.S., of the Hunterian Museum, were sectioned by him, and are now in "The Young Collection" in the Kelvingrove Museum, Glasgow.

During the recent visit of the British Association to Glasgow in 1901, an excursion was made to the Downtonian beds exposed in the Birkenhead Burn, and through the kindness of Miss Slimon the collection made by her father was laid out for the inspection of the members. It was then discovered by the writer that Dr. Slimon had actually collected specimens of those Upper Silurian fishes, including one of *Thelodus* from the Ludlow rocks, and one of *Birkenia*, probably from the same bed; and he has since found in the Hunterian Museum several nodules containing remains of *Thelodus* more or less perfect, which had been presented to the museum by Mr. James Young previous to his discovery of the complete fish, as already mentioned, though their character and importance had evidently been overlooked.

The first discovery of these beds is due therefore to Dr. Slimon, and the recognition of their geological importance to Sir Roderick Murchison, but as to the fish-remains, the honour cannot be so easily settled. Dr. Slimon really found them first, but did not know what they were, while those afterwards collected by Dr. Hunter were pronounced by Dr. John Young to be remains of fishes, but not identified. Mr. James Young of Lesmahagow, though thus only the third to get *Thelodus*, was the first to find an entire fish, but it was his discovery which undoubtedly put

Digitized by Google

A SECTION IS HERE GIVEN SHOWING THE STRUCTURE OF THE UPPER SILURIAN INLIER OF LESMAHAGOW FROM SEGGHOLM TO YONDERTOWN.



Section across the Lesmahagow Upper Silurian Inlier from Seggholm to Yondertown, (Distance about nine miles.) After the Geological Survey.

*d*2. Lower Carboniferous formations.

*c*1. Lower Old Red Sandstone.

Downtonian.
- 6*e*. Chocolate-coloured Sandstones.
- 6*d*. Quartzite conglomerate.
- 6*c*. Fish-beds.
- 6*b*. Red and Yellow Sandstones. The Glenbuck conglomerate band (6*a*) is not here present.

Ludlow.
- 5*f*. Greywackes and Mudstones.
- 5*e*. *Trochus*-beds.
- 5*d*. *Pterygotus*-beds.
- 5*c*. *Ceratiocaris*-beds.
- 5*b*. Shales and Greywackes.

5*a* Wenlock (?). B. Dolerite Dykes (Tertiary). *f* Faults.

Digitized by Google

the Survey Officers upon the scent, resulting in the wonderful additions to the Silurian fish-fauna of Scotland by Messrs. Macconochie and Tait. We are indebted to Dr. Traquair for their determination and description.

In 1899 the first "Camp Siluria" was pitched in a bend of the Logan Water, above Logan House, under the direction of Mr. James Young, for the purpose of working the beds in which he had found the *Thelodus* some three years previous, and in which Dr. Hunter had also found the *Palæophonus* earlier.

During that summer a number of fine specimens of *Thelodus*, *Ceratiocaris*, and *Pterygotus* were found by Messrs. Young, Nimmo, and Clarkson, many of them being presented to the Kelvingrove Museum. Amongst the more important finds of the year may be mentioned the typical Upper Silurian brachiopod, *Lingula Lewisii*, which had not been previously recorded from the Lesmahagow inlier, though found by Mr. John Henderson in the ravines of the North Esk in the Upper Silurians of the Pentland Hills. *L. Lewisii* is present in the Woolhope beds, the Wenlock limestone and its shale, the Lower Ludlow, and the Aymestry limestone of England. The discovery of this typical Upper Silurian form in the Logan Water bed helps to further confirm its exact geological position. Another interesting specimen found during this year's excavations shows the abdominal segments of a crustacean, which possessed several distinct pairs of swimming feet, and resembled *Ceratiocaris*.

In the summer of 1900 it was determined to shift the camp to the Birkenhead Burn, for the purpose of working the Downtonian beds exposed in the deep ravines cut by the stream, and so it was pitched below a protecting cliff of the Great Conglomerate. Looking from the heights down the stream we could espy the cairn-capped summit of Tinto, and when the rays of the sinking sun struck upon the western side of the great corrie, the pink felsite, of which the mountain is composed, glowed as if it were on fire.

The routine of everyday life in the camp may here be briefly described. Morning has scarcely begun to dawn when signs of life within the tent become evident; the doorway is unloosened, revealing a head protruded to inspect the weather, for that is the all-important point. Some one climbs the

Digitized by Google

Digitized by Google

I. "At Work on the Fish-bed," Logan Water, Lanarkshire.

II. "Camp Siluria," Logan Water, Lanarkshire.

From Photos by David Nimmo. *Hislop & Day, Photo Engrs.*

Digitized by Google

neighbouring height to scrutinize the summit of the great hill, for we, like the "auld wives" of Symington, have considerable faith in its powers as a weather prophet. As the old saying runs:—

> "When Tinto tap puts on her cap, and Coulter on her coul,
> The auld wives of Symington say it will be foul."

As it seems, no fears need be entertained for this day, at least; the sky is clear, and the distant outline of Tinto is already becoming well defined. By this time all inhabitants are astir, and half a dozen geologists, all told, are busy. One man is pumping at a "primus" stove, as if it were a case of life and death. Another is rushing about with a rasher of bacon in one hand and a couple of eggs in the other, while a third is busily washing the dishes. Even at this early time of the morning, for it cannot be later than five o'clock, the remaining three are already deep in some profound geological problem, having innumerable geological maps and sections spread out before them, and are busy discussing the throw of faults, the outcrop of conglomerates, and the position of the fish-beds. When the dishes have been put away, and the blankets put out to air, a move is made by some of the party upstream to a large pool where a morning dip is indulged in, followed by a run through the heather—

> "Oh the wild joys of living! the leaping from rock up to rock,
> The strong rending of boughs from the fir tree, the cool silver shock
> Of the plunge in the pool's living water . . .
> How good is man's life, the mere living! how fit to employ
> All the heart and the soul and the senses for ever in joy!"*

A start is now made about a hundred yards up the burn to a cliff, where the work of the day is to take place. The first man in the procession has a "pinch" on his shoulder, the second a pick, and the third a shovel; while the remainder are armed with hammers of various shapes and sizes—some for breaking up hard blocks, and others for splitting the finely laminated rock in which the fossils we are in search of are to be found. A considerable amount of rock has to be removed before the fossiliferous bed can be reached. Eventually, when the underlying bed is laid bare, pieces of the rock are passed over to those who wield the

* "Saul," by Robert Browning.

Digitized by Google

splitting hammers, and the excitement begins. After some time expended in fruitless work, a cry at length rends the air, "A *Lanarkia*, a *Lanarkia*," and immediately a rush is made to inspect the find. Drawing closer, we see that the worker is busy with a fine chisel and hammer removing a layer, beneath which something like a dark brown stain is showing itself. Whenever this has been finished, something uncommonly like the tail of a fish is laid bare, and after about a quarter of an hour's work the entire form of the fossil lies revealed.

There can now no longer be any doubt—*Lanarkia* is a fish. Clearly outlined upon the stone is the figure of a fish, and a quaint one it must have been. The head and anterior part of the body are of a flattened trapezoidal shape, broader behind than in front; the sides swelling out into flat-like projections, sharply marked off from the tail, behind which comes a deeply bifurcate and strongly heterocercal caudal fin, and one of the most characteristic features of this fish, the dermal armature, consisting of little conical hollow spines without a basal plate. In the specimen just found, and in fact in all the specimens which have as yet been found, there is no evidence of the existence of mouth or eyes, only the outline of the head, the body, and the tail being shown.

Another long period elapses, during which great masses of rock are detached from the hillside. It seems as if our luck has deserted us, but that does not cause despair, as we have sometimes hammered here for a whole day without obtaining a single fossil worth taking home. We have even worked for a week without finding a really good specimen, till perhaps on the last morning, on despairingly taking a last parting shot just before leaving for town, a very fine fish might be turned out. So on this day, when things are looking dull, and backs and arms are becoming sore, a shout again makes the welkin ring—"A *Birkenia*, lads; a *Birkenia*"—and a ring of eager faces is formed round the discoverer. This time the whole fossil has been laid bare at a stroke, and it is again a fish, but wholly unlike the *Lanarkia* previously spoken of. In fact, it is so unlike any other fishes hitherto known, that Dr. Traquair has felt the necessity of forming a new order for its reception. He describes it as follows:—"The genus *Birkenia* is fusiform;

Digitized by Google

body covered with several longitudinal rows of narrow scutes, arranged in lines running obliquely from above downwards and forwards; head bluntly rounded, also covered with narrow scutes; an oblique row of small round openings on the side just at the posterior boundary of the head, no orbit seen, and no evidence of cranial bones, jaws, or shoulder girdle, no paired fins, caudal palæoniscoid in shape, completely heterocercal, deeply bilobed and rayed; a small rounded dorsal, situated far back near the caudal."

But the sun is now high in the heavens, and a halt must be called for dinner. So, somewhat exhausted with the hard work of the morning, we retrace our steps to the tent and begin preparations for the mid-day meal. After dinner, tobacco is produced, and, lying around on the grass, we enter into discussions more or less profoundly palæontological and stratigraphical. One favourite and ever-recurrent subject is the physical conditions which obtained during the deposition of the rocks on which we have been at work. Some of the party maintain that they must have been laid down in freshwater lakes, others that they were estuarine, while a third group contend they were of marine origin; the estuarine and marine theories, however, carry the day.

About six o'clock in the afternoon, digging being stopped for the day, we again assemble at the tent for tea. Then comes more talk round a roaring camp fire, when all sorts of subjects in literature, science, and philosophy, including the use of the pathetic fallacy by Tennyson, the philosophy of the unconditioned, and the zoological affinities of the organisms disinterred during the day's operations, the last mentioned being the favourite. Upon one point there is general consent—that in the hands of the distinguished President of our Society, Dr. Traquair, the fishes from the Downtonian and Ludlow beds have thrown a flood of light upon the origin and descent of the Ostracodermi. Also that as no record of his investigations into these most interesting fish-remains has yet been placed in our *Transactions*, it is desirable that a short summary of them should now be given.

It is somewhat interesting to remember that a fish generically identical with the *Thelodus* of the Downtonian and Ludlow beds of the Lesmahagow Silurians was long ago found by Dr.

Digitized by Google

Powrie* in the Lower Old Red Sandstone of Turm Hill, near Forfar. This specimen was acquired in the year 1892 for the Edinburgh Museum of Science and Art, along with the rest of the Powrie collection. In the course of time Dr. Traquair was enabled to announce the identity of Powrie's *Cephalopteris* with the *Thelodus* of Agassiz, the latter genus having been founded on certain minute scales, which Agassiz had looked upon as teeth, and which had been found in the Ludlow bone-bed of the Upper Silurian rocks of Shropshire.

The discovery of a complete *Thelodus* in the Upper Silurian rocks of Lanarkshire showed that, though the fish had a shark-like appearance, it could scarcely be considered a true selachian. Dr. Traquair thus describes its appearance:—"*Thelodus Scoticus*, Traq.—It has a broad, flattened, anterior part corresponding to the forepart of the body, very bluntly rounded in front, and passing behind into right and left angular flap-like projections, which are sharply marked off from the narrow tail, which is furnished with a deeply-cleft heterocercal caudal fin. Unless the flap-like lateral projections are representatives of pectorals, no other fins are present; neither do we find any teeth or jaws, nor any trace of internal skeleton." And he further says:—"Only a few days ago Mr. Tait, collector to the Geological Survey, pointed out to me in a recently-acquired specimen a right and left dark spot at the outer margin of the head near the front, which might indicate the position of the eyes."

It ought, however, to be added that since the above was written Mr. James Young of Lesmahagow has found a specimen of *Thelodus* with a well-defined dorsal fin.

In general contour the genus *Lanarkia* presents much the same features as *Thelodus*, but instead of being covered by the well-known minute scales, its dermal armature consists of relatively large conical spines without a basal plate. *Lanarkia* is considered by Dr. Traquair to represent the least specialised member of the Ostracodermi, and I think he has shown most conclusively the line of descent of such highly specialised types as *Pteraspis* from such a comparatively simple form as *Lanarkia*.

But the night is getting somewhat chill, so we retire to our

* Powrie named the fish *Cephalopteris Pagei*, his original specimen being described and figured in the *Transactions* of the Edinburgh Geological Society, vol. i., 1870, p. 298.

Digitized by Google

tents, and lace up the doorways. The Chinese lanterns are lit, and by universal consent the philosopher and poet of the camp is requested to read extracts from the works of some of the masters. Tennyson, being his favourite poet, is naturally chosen, and nothing interrupts the sounds of his voice except the occasional rippling of the burn over its stony bed. Shall we be ashamed to confess that perhaps the last sound of which we were conscious was when our reader quoted that exquisite gem in which the great poet has crystallized the principles of modern geological science—

> "The moanings of the homeless sea,
> The sound of streams, that, swift or slow,
> Draw down Æonian hills, and sow
> The dust of continents to be?"

Digitized by Google

No. XXIII.—A Stroll along a Trap Dyke in the Parish of Beith, Ayrshire. By James S. M'Lennan, Hon. Librarian.

[Read 13th February, 1902.]

The study of local history, whether from its historical, domestic, or scientific side, has always been attractive to many enquirers, and especially to those connected with the particular localities by birth or other ties. The small rural English parish of Selborne would, in all likelihood, have remained a mere name, but for the observant eye and graceful pen of the Rev. Gilbert White, the curate of this his native place, whose "Natural History of Selborne" has become a classic of English literature, and has given the district a world-wide fame.

Amongst the members of our own Society there have been not a few who, to our great advantage, have recorded the characteristic geological and other interesting features of the districts with which they were best acquainted, and have thus considerably added to the available records of local science.

Our late, and much regretted, member, Robert Craig, who, during a long and busy life, gave a large share of time and study to the geology of Beith, his native parish, did much to make its name well-known amongst geologists, and he latterly became one of the leading authorities on the geology and palæontology of Northern Ayrshire. A number of his papers have been published in the Society's *Transactions*, and, as will be seen, some of them have been of use to me in the present paper.

That portion of the parish of Beith which abuts on Renfrewshire consists largely of igneous rock, contemporary with those of Calciferous Sandstone age. It forms part of the Renfrewshire and Ayrshire hills which extend from near the town of Beith to Darvel and Strathaven, and rises like a long island through the Carboniferous limestones, whose lower beds are tilted up, and rest against it. "Thus," says Mr. D. Bell, "on the southern side of these hills we have the Lower Limestones of Beith succeeded by the overlying Coals and Ironstones of Dalry, and these again

Digitized by Google

by the 'Upper Coals' of Kilwinning and Kilmarnock; just as on the northern side we have the Lower Limestones of Howwood and Barrhead succeeded by the overlying Coals and Ironstones of Johnstone and Govan, and these, again, by the 'Upper Coals of Rutherglen, Hamilton, and Airdrie."*

The same igneous rocks also extend over nearly all the parishes of Dunlop, Stewarton (upper part), and Fenwick, into Renfrewshire, and much of the surface in this widely-extended region is covered by moss and moorland. South of the elevated exposure of trap-rock in Ayrshire there is a thick expanse of Carboniferous limestone, rich in the remains of marine fishes and molluscs, with overlying beds of coal and clayband ironstone which have been worked in several places, as at Caldwell, Balgray, Barr, Bogston, Barkip, and the Den.

The valley east of Beith, through which the Lugton Water flows, separating it from Dunlop parish, is traversed on its western side by the road from Irvine to Glasgow, locally known as the Lochlibo road; and where it crosses that from Beith to Dunlop, near the small village of Burnhouse, I propose to begin our "Stroll along a Trap Dyke," one of those many long well-defined dykes of dolerite, or fine-grained basalt, which traverse the central valley of Scotland, generally with a north-west and south-east trend.

The dyke on which our present course lies, stretches from near the villa of Burnhouse to the farm-steading of Craighouse, a distance of 3½ miles, and so nearly north-west to south-east. Its bare and rocky upper surface has been used as a natural highway from the days of pack-horses, or before then, down to the present time. On its northern side for most of the way there is a steep escarpment, but on the south one it meets the surface-level. At the eastern end, where it has been quarried, close to the farmhouse of Giffen, it forms a circular height which rises a hundred feet above the plain, and once bore on its summit the ancient castle of Giffen. Below this the dyke has a narrow fringe of trap-tuff. To the north the traps of Calciferous Sandstone age extend for half a mile, when they are overlaid by the limestones.

The Castle of Giffen itself is now only a name. The height on

* From No. III. of a series of papers—"With the Geologists"—by the late Mr. Dugald Bell, F.G.S., printed in the *Evening Times* in 1883.

Digitized by Google

which it once stood is composed of a dark-coloured, clean-cutting trap, which in some places encloses masses of shale and sandstone. It is being quarried for road-making purposes, so that now the very site of this interesting old relic of bygone times has nearly disappeared. The old building, whose walls were 30 feet square, 6 feet thick, and 40 feet high, ceased to be inhabited about the middle of the eighteenth century, but having fallen into a ruinous condition, the western wall was broken down, probably to furnish building material for farmhouses and cottages, a common fate of such remains of antiquity till within the last half century, since which time they have been usually treated with more respect. The remaining walls are said to have fallen with a loud crash on 12th April, 1838. The castle and the surrounding lands belonged to a branch of the Eglinton family from A.D. 1370 to 1722. Amongst them was Sir Henry Montgomery, whose wife, a correspondent of the well-known Samuel Rutherford, was life-rented in it for fifty years after the death of her husband; but the most famous member of the family was Francis Montgomery, who took an active part in the Union of Scotland with England in 1707, and was afterwards member for Ayrshire in the United Parliament.

A short way west of this was "The Moot," now called Greenhills, where the Baronry Court was held, and here also were the joiner's and the blacksmith's shops, and it is worthy of note that these industries still survive on the same spot. A fine modern schoolhouse has recently been built on the dyke at this place, and makes a feature in the landscape.

From a little west of Greenhills, where it reaches its greatest elevation, a fine view of the valley of the Dusk is to be had. Looking north we see the upper part, with the woods surrounding the old castle of Hessilhead, the birth-place of Alexander Montgomery, author of "The Cherry and the Slae." It is a romantic spot, with its low cliffs, and the ivy-clad ruins, the more recent of which bears the date of 1608.

Where a quarry has been recently opened near this height, the northern side of the dyke is almost quite perpendicular. The limestone seems to have been very little changed by contact with the trap, which also shows small traces of any alteration from the enclosing limestone. On the southern side the basalt has been

Digitized by Google

considerably broken up and denuded away, and here we pass a patch of trap of long prior date.

Proceeding down the eastern side of the valley, where the rock has been long quarried, we reach the bridge carrying the new Lanarkshire and Ayrshire Railway across the highway. Near by, and a little way above Giffen Mill, a fine exposure of black shale is cut into, and this, according to the Officers of the Geological Survey, is surrounded by the trap of the dyke.

It should here be noted that a little way eastward from this railway bridge the dyke crosses the "Great Fault" which extends from Ardrossan up the Dusk Valley and through Ayrshire into Renfrewshire, causing a downthrow of 200 fathoms near Dalry, which has let down the Dalry coalfield, and so, fortunately, preserved it from denudation. It has also caused a great break in the ridge of trap-rocks to the north of Lugton, and along this line the various denuding agencies have hollowed out the glen through which the Glasgow road runs.

Crossing the Dusk in our westward march, we pass a linen-thread factory, and the little village of Barrmill, with, to our left, a small triangular enclosure containing the graves of twenty of its inhabitants who died of cholera in the year 1846. We now reach the Limestone Series, with its seams of coal and ironstone. The coal was wrought here for many years before 1870, and further north pits were sunk in the lands of Balgray, but ceased operations over fifty years ago. At present, a clayband ironstone pit close to Barrmill Station is being worked.

Beyond the little burial-ground at Barrmill the land rises, and on the northern side the dyke has a steep escarpment, where its upper part, of dark-coloured, fine-grained rock, has been quarried for many years. Here there once lay, at the base of the cliff, a small, narrow lake, which is now drained, and its bed converted into moss land. On the south side coal has been mined in several places, as at South Bar, Drumboy, Bogston, and the neighbourhood of Bankhead.

Some fine examples of slickensides may be seen on the right-hand side of a passage cut through the shale surrounding the dyke on the northern side, so that it might be quarried at a lower level. In some places, this shale, which mostly lies in its natural position, the layers being only slightly tilted up, has been affected

Digitized by Google

by the heat from the trap, which has driven off its carbon, leaving it nearly white. On the southern side a sandstone, also lying nearly horizontal, has been cut through.

Away to the south-west an extensive overflow of trap of Carboniferous age separates the Coal-measures proper from the Limestone Series. It forms a ridge running four miles to the south, and having, in the vicinity of Giffen House at that end, a high bank, which is the most prominent feature in the landscape, and is seen throughout the entire area of Giffen Baronry. A considerable extent of land near the base of this escarpment is overlaid by peat-moss, but the coal and ironstone seams underlying it and the surrounding district are now nearly exhausted, having been mined for more than fifty years.

Passing the farmhouse of North Barr, built on the dyke, we reach a small circular elevation, composed of loose and sandy clay, and surmounted by a clump of tall beech-trees, which, in bygone days, contained the only rookery in the district. From this the dyke slopes gradually, but is not exposed to view till it reaches "The Belcraig," where its ridge is seen running parallel with the road from Barrmill to Beith. Here, where it has been quarried, its upper portion is seen to be coarser in grain than the rock further to the east. For the next half mile its course is not visible. On its southern side, near Windyhouse, the clayband ironstone was once wrought for a very short time.

North of this the wide expanse of limestone has been quarried in various places for a long period, being extensively used as a flux at the Glengarnock Ironworks. The quarry in its beds near Dockra, and others in the neighbourhood, were for many years "the happy hunting-ground" of the West of Scotland fossil-collectors, and one of Mr. Craig's papers,* read before the Society, gives an exhaustive list of the genera and species found in them.

In the Hand-books issued for the Meetings of the British Association in Glasgow in 1876 and 1901 there will also be found extensive lists of the fossils found in these strata, with descriptive notes on the various localities.

Proceeding westwards we soon reach the ridge on the eastern side of the basin of the Powgreen (Marshland) Burn, where there

* "Sketch of the Carboniferous Basin of Dalry, Ayrshire." *Trans.*, vol. iii., part 2, 1869, page 271.

Digitized by Google

is a fine view of the Spiers' Academy School, a handsome building erected and endowed by the late family of Spiers, of Beith. A short way beyond this stands the parish church, which, from its conspicuous position, has long been locally known as "The Visible Church."

Close to the burn the dyke is exposed in a quarry near the Tarroof, and makes its last appearance at the farmhouse of Craighouse, where its dark escarpment can be traced for some distance till it ends its course about 400 yards to the west. Throughout the whole way of 3½ miles its breadth varies extremely little, never much exceeding 200 yards. For most of the distance it traverses either the limestone, or one of the members of the Limestone Series, though for a very short space on the north side at Giffen, and again at Greenhills on the south, it cuts through patches of trap rock of much older date.

Digitized by Google

No. XXIV.—Notes on Excavations in Glasgow. By John Wallace.

[Read 12th October, 1903.]

I have always thought it a pity that important facts regarding the surface geology of the city area, which are brought to light from time to time in connection with the excavations for the foundations of new buildings, deep-level drains, or other openings, should be allowed to go unrecorded for want of some one who would undertake to keep an eye upon them; and as I have for some time been making notes on recent exposures, I propose to-night to give you a short paper on the subject, in continuation of at least one previous one which I read before the Society.*

In these days of rapid building, the opportunity for seeing an underground exposure is often extremely limited; at the utmost, a few weeks, perhaps curtailed to days, or even hours, and if the chance is lost it may be long before a similar one occurs. I shall therefore be extremely obliged if any of the members will give me early information about such openings, so that I may be able to record the observable data, be they few or many.

Those excavations of which I have taken some notes, though unfortunately not so many as I could have wished, from want of time, are five in number, as follows:—(1) the corner of Trongate and Nelson Street; (2) the Arcade Frontage, Buchanan Street; (3) the Extension of the Fruit Bazaar, Nelson Street; (4) the Technical College, George Street; and (5) the corner of Trongate and Candleriggs.

1. *The Corner of Trongate and Nelson Street.*—A valuable section is at present exposed here. It is about 115 feet long by 20 feet deep. At the bottom occurs a very thick deposit of extremely finely laminated clay, with partings of fine sand, dipping S.W. at about 30°. In some places it showed most beautiful bands of colour, some a light-blue grey, and others a

* "Notes on a Recent Excavation in Sauchiehall Street." *Trans.*, vol. xii., part 1, 1902, page 79.

Digitized by Google

light to a very dark brown. It could be pared with a knife to the thinness of a sixteenth of an inch. A lump of it put into water dissolved in a minute or two, causing a heavy turbidity which took a long time to settle down. Its thickness is more than 100 feet.

Lying above it is a bed of pinkish laminated clay mixed with patches of fine grey sand. In this bed were two boulders about 100 feet apart, and nearly 3 feet in diameter, one of dolerite and the other of sandstone. At the north end of the section there was a rather strange-looking bed of ferruginous sand, about 6 inches thick, of a deep red colour, and changing towards the south to a black-brown. The upper part of the section consisted of three distinct beds of current-bedded sands and very coarse gravels, with pockets and "bings" completely made up of pebbles of coal and carbonaceous shale. It is worth any one's while to go down and examine this most interesting section before it is finally closed up.

2. *The Arcade Frontage, Buchanan Street.*—This section, as seen from the back looking towards Buchanan Street, was very fine. From the pavement level it went down about 13½ feet, and was 54 feet long. It contained the following beds in ascending order, all dipping S. at about 6° :—On the bottom a thick bed of fine grey laminated sandy mud, and above it one of fine grey sand. Then 9 inches of clean sharp sand; 6 inches of sand with layers of pebbles of coal; 3 inches clean sharp sand; a bed of coarse sharp sand which contained a few large boulders, and some concretions due to iron. On the top of all lay a thick bed of heavy loamy soil. There has to be some further and deeper excavating here, which may yield some interesting facts when it is examined, as I hope to be able to do.

[For the facts given about this section I am indebted to the kindness of Mr. Drinnan, clerk of works on the buildings.]

3. *The Extension of the Fruit Bazaar, Nelson Street.*—I had only two or three opportunities of visiting this interesting section, and then a portion of it was already covered up by the foundations of the new building. The lowest bed exposed here consisted of 9 feet of sands, gravels, and clays, in which was found at least one boulder of dolerite bearing marks of glaciation. Above this there was a 3 feet 6 inches bed of fine porous sand

Digitized by Google

containing many curious-looking markings, caused probably by the infiltration of water loaded with iron from its passage through a 9-inch bed of coarse sand which lay on the top. These markings might be due to movement, though that did not seem altogether probable.

4. *The Technical College, George Street.*—This excavation I was able to visit only once last year. There was then to be seen a section of stratified sands and clays, some of the beds containing small boulders evidently washed out from some Boulder-clay bed. In a fine bed of sand there were found a great many concretionary nodules, which, when broken open, showed most beautiful concentric bandings, not unlike those seen in agates, some of them being as large as a foot in diameter. The specimens placed before you to-night are the only ones I know of which have been preserved. As a great amount of excavation has yet to be made here I expect to get some facts of interest from the exposure before the foundations are laid.

5. *The Corner of Trongate and Candleriggs.*—This was a small section which I examined about three years ago, when I found that it contained a fine series of sands, clays, and gravels. In the upper part of it were to be seen quantities of rootlets of plants quite carbonised, and penetrating downwards about 4½ feet from the top.

The author then went into some speculations regarding the derivation of the various beds occurring in the local excavations—sands, gravels, clays, laminated clays, and boulders—recorded in the above notes.

The paper was illustrated by diagrams and sections.

Digitized by Google

No. XXV.—The Cambrian Fauna of the North-west Highlands.

By B. N. Peach, LL.D., F.G.S., of H.M. Geological Survey.

[Read 12th March, 1902.]

(Summary.)

The Cambrian strata of the North-west Highlands extend as a narrow belt from Durness and Eriboll in Sutherlandshire to the district of Sleat in Skye. They consist of a basement quartzite, a middle group of shale, dolomites and grits; the Fucoid beds and Serpulite Grit, and upper group of dolomites, limestones and cherts — the "Durness Limestone." These were evidently deposited along the shore of the gently-sloping land-area which lay towards the north, and which gradually subsided, the "Durness limestone" bearing evidence of having been deposited in clear water free from land-borne sediment. Their contained fossils are markedly American in facies, unlike those in rocks of corresponding age in England and Wales, Scandinavia, Russia, Bohemia, France, Spain and Sardinia. From these facts it was inferred that in Cambrian times there had been free migration of species along the shore-line of a continent lying across what is now the North Atlantic Ocean to Arctic Europe; and that clear deep sea, and not a land barrier, prevented their migration into the other European areas. The position of this sea is indicated by the radiolarian cherts which occur in the Arenig rocks of the southern uplands and the Highland border.

If these inferences are correct, then the plication and metamorphism of the Central Highland rocks is post-Cambrian in date. This supposition is strengthened by the fact that the "Durness Limestone," the upper members of which contained an Upper Cambrian or Ordovician fauna, and the radiolarian cherts, presumably of Arenig age, are respectively involved in the northern and southern edges of the great "fan" into which the rocks of the Central Highlands have been thrown.

Digitized by Google

No. XXVI.—The Vertebrate Animals of the Coal Period. By R. H. Traquair, M.D., LL.D., F.R.S., &c., *President.*

[Read 10th April, 1902.]

(Summary.)

Dr. Traquair stated that the vertebrate fauna of the Coal period was confined to fishes and amphibia, no remains of reptiles, birds or mammals having yet been discovered in Carboniferous rocks. The fishes belonged mostly to groups which are scantily represented, or nearly extinct at the present day. Abundant selachian or shark remains had been found, chiefly as scattered teeth and spines, so that it was difficult to form an idea of the special affinities of the creatures when entire. No doubt could, however, be entertained of the affinity of some of the Carboniferous sharks to the recent Notidanids, and of others to the Cestracionts or "Port Jackson sharks," while two orders, one of which contained the singular genus *Pleuracanthus*, and the other the problematic Acanthodians, were entirely extinct. Of Teleostomous fishes, the group of Crossopterygii, now reduced to the African genera, *Polypterus* and *Calamoichthys*, was abundantly represented by the extinct families of Osteolepidæ, Rhizodontidæ and Cœlacanthidæ, some of which, as *Rhizodus*, attained a great size. The "lung fishes," now reduced to three genera, *Ceratodus*, *Lepidosiren*, and *Protopterus*, were represented in Carboniferous times by *Uronemus*, *Ctenodus and Sagenodus*. The sturgeon-like fishes, now nearly extinct and reduced to a few degenerate forms, were abundantly represented in Carboniferous waters by the long-extinct families of Palæoniscidæ and Platysomidæ. The former consisted of elegant fishes shaped something like a modern roach or trout, but having rhombic ganoid scales often beautifully sculptured, and heterocercal tails. The latter family seemed to be a specialised offshoot from the Palæoniscidæ, in which the form of the body was deepened, the scales were high and narrow, and the bases of the median fins were elongated. As regards the

Digitized by Google

geological bearings of Carboniferous ichthyology, the lecturer stated that the fishes in the marine beds of that formation were different from those in the beds of estuarine origin, and also the fish-fauna found in the Lower Carboniferous rocks was mostly different as to species, and frequently as regarded genera, from that in the Upper Carboniferous division. Few species passed the boundary of the base of the Millstone Grit, and as regards the question of life-zones in the Carboniferous system, the fishes found fossil in it enabled us, in Britain at least, to define only two such zones—Upper and Lower. The Amphibia were represented in Carboniferous times only by the extinct order of Stegocephalia or Labyrinthodontia. Two well-known forms from the Upper Carboniferous rocks of Great Britain were *Anthracosaurus* and *Loxomma*, which last genus also occurred along with others such as *Pholidogaster*, in the Lower division of the system. The older Carboniferous Labyrinthodontia have not yet been fully investigated.

The lecture was illustrated by diagrams and photographs shown by the oxyhydrogen lantern.

Digitized by Google

No. XXVII.—Notes on a Recent Trip to Egypt. By James Neilson, Milnbank.

[Read 29th May, 1902.]

(Summary.)

At the outset the author described in some detail the geographical aspect of the country. He then mentioned the temples and monuments which he had visited, particularly noting the rock-materials of which they were composed. Some of these buildings were entirely of alabaster, formed as a secondary deposit in the caverns which had been hollowed in the Tertiary limestone, while others were composed of the limestone or the granite of Assouan, or of the Nubian sandstone. He then gave an account of various geological phenomena observed by him. One group of beds on the opposite side of the Nile from Assouan seemed to be identical lithologically with our own Carboniferous rocks, with the Arran section of which they might be compared on account of the way in which they had been altered by the neighbouring granite. The general similarity was heightened by the occurrence of beds of ironstone and carbonaceous deposits, contained charred plant-remains. Another highly interesting section showed an intrusive boss of quartz surrounded by mica-schist. The occurrence of a large number of blocks of the petrified wood of an exogenous tree in the loose sand overlying the nummulitic limestone near Cairo was also described, while overlying the petrified forest was a bed of sand containing numerous beautifully-rounded water-worn pebbles, mostly of quartz. It was not easy to account for the origin of these pebbles, as the nearest rocks containing quartz, which Mr. Neilson had seen, lay something like 600 miles further south. On the surface of the desert sands he had picked up specimens of marine shells of recent species, not only at the petrified forest, but as far up as Sakkara, the most frequent being a species of *Petunculus* identical with that presently living in the Mediterranean Sea. A vivid account of the various physical

Digitized by Google

changes which the area had undergone was afterwards given. In conclusion, Mr. Neilson referred to the great quantities of palæolithic and neolithic Flint Implements which were to be found in Egypt, and which in his opinion showed that it had been inhabited for at least as long a period in pre-historic as it had during historic times.

The paper was illustrated by a large series of lantern slides, specimens of fossils, and of stone and flint implements.

Digitized by Google

No. XXVIII.—Volcanoes: their Causes and Effects.

By J. G. Goodchild, F.G.S., of H.M. Geological Survey.

[Read 9th October, 1902.]

(Summary.)

The lecturer began by considering the sources of the heat which is one of the prime causes of volcanic action. It is not, he thought, a vestige of the molten globe, but is largely due to dynamic causes such as have been in operation in all periods of the Earth's history, and which are acting now quite as energetically as they have ever done in the past. The movements of elevation and depression to which the larger inequalities of the Earth's surface are due, and which give rise to both the oceanic depressions and the continental elevations, can be proved to be still in progress, and there is no reason for believing that their effects are in any way different at the present day from what they were in former times. He advocated the view that the heat generated by terrestrial movements is the prime source of the high temperature occurring in connection with volcanoes. The zones of the crust of the Earth where these movements operate with most effect are along the marginal areas of the great depressions, which are occupied in most cases by sea-water, or in a few others by the saline waters of the lakes occurring in the areas of inland drainage. The waters from these sources made their way downward into the inner zone of the Earth's crust, and did so more readily along the great belts undergoing disturbance than elsewhere. Hence it is along the subterranean zones, where the temperature of the rocks is raised above the normal by the conversion of the energy of motion into the energy of heat, that alkaline and other substances dissolved in water are carried in by osmosis and other causes in larger quantity than elsewhere. Alkaline waters, at even a moderately high temperature, are competent to dissolve most of the rock-constituents of the Earth's outer envelope. But the tendency to pass into the fluid state under the influence of

Digitized by Google

these causes is partly counteracted by the enormous pressure exerted by the overlying masses of rock nearer the surface. This pressure is relieved locally during terrestrial movements, and especially so along the crests of the larger folds, such as those to which both the marginal uplands of continents and the great oceanic ridges are due. With the relief of pressure arising in this way part of the rock passes into a more fluid state, and at the same instant that this happens superheated water, occluded within the rocks, flashes with explosive violence into steam. Hence arise earthquakes, which may be likened to tremendous boiler explosions. The earthquake shock in its turn operates upon the surrounding rock-materials in much the same manner as the explosion of dynamite does in a quarry. More rock is loosened, and the extent over which the pressure is relieved becomes greater at each repetition of the blast. This goes on until in the end the centres of explosion have worked their way close to the surface, when a vent opens, and a volcano starts into existence. This explanation harmonises with all the facts known in connection with existing volcanoes, and therefore applies also to those of the past, in which geologists are more especially interested.

Volcanoes occur almost exclusively in areas at no great distance from regions undergoing depression on the one hand, and are found, on the other hand, equally close to other areas which are undergoing upheaval. Hence in the cases in which the age of a zone of volcanoes has been determined we may go further, and assume that adjacent depressions of the surface are of the same date. Thus the formation of the great depression of the Atlantic at the Bay of Biscay probably dates from the time when the Pyrenean volcanoes were coming into existence. The evolution of the Mediterranean depression, in like manner, may on the same grounds be assumed to have been contemporaneous with the earlier stages of the volcanoes of Italy, Sicily, and the Grecian Archipelago. The initiation of the great submarine depression off Japan may also date back to the time when its volcanoes first saw the light. So, too, with the Javan volcanoes, including Krakatoa, which may bear the same kind of relation to the adjacent large area of depression of the Indian Ocean. The steep slopes and great oceanic depths around Hawaii may be similarly connected with the evolution of the Hawaiian volcanoes.

Digitized by Google

Lastly, the Windward Islands, which form a great ridge squeezed up between two deep troughs whose bottom lies between nine and ten thousand feet below the surface, may, on the same grounds, be regarded as resulting from the same set of terrestrial undulations as those to which the recent disastrous volcanic eruptions of the West Indies have been due.

The time required to build up a volcano, based chiefly upon facts gathered upon Etna, was remarked upon. These appear to suggest that this volcano may have taken three millions of years to reach its present state. As it lies upon rock very little older than the Forest Bed of East Anglia, in which nearly the whole of the organic remains, except those of the larger mammalia, are of existing species of animals, its age affords a measure of time which becomes an important factor in computing that of the Earth.

The lecture was illustrated by a fine series of photographs, some taken by Dr. Tempest Anderson, which were thrown on the screen by the oxyhydrogen lantern.

Digitized by Google

No. XXIX.—"The 'Green Beds' on Sron Aonaich and near Ardlui, Argyllshire." By Peter Macnair.

[Read 14th November, 1902.

(Summary.)

Stratigraphically the "Green Beds" occur in a position near the top of the lower arenaceous zone, and occupy a horizon not far below the Loch Tay limestone. It was not until considerable advances had been made in the mapping of the Highlands that the Officers of the Survey were enabled to recognise the importance of the rocks as a definite and well-marked horizon amongst the schists to the south of the Loch Tay limestone, below which and towards the great central *facher* or fan structure the "Green Beds" dip in simple outcrops below the Loch Tay limestone. Between the great axial line of folding and the frontier Highlands they are repeated again and again in isoclinally-folded strata as outliers between the folds of the Ben Ledi grits. In Cowal there appear to be two sets. The particular specimens from which those exhibited have been taken are on Sron Aonaich, a shoulder of Ben Lomond, and in the railway cutting on the West Highland line north of Ardlui, the principal interest attached to them being the increasing metamorphism seen in the rocks from the latter locality.

The Sron Aonaich "Green Beds" are principally pale yellowish greeny grits, the original clastic structures being quite apparent, as they often enclose large pebbles of quartz and felspar. Examined in a thin slice under the microscope the rock is seen to be composed of epidote, quartz, felspar, chlorite, biotite, and two sets of long needle-shaped crystals, one of which gives straight extinction and has a positive sign, while the other has an extinction angle of about 14 degrees, and may be hornblende. The epidote is in small rounded grains, appearing to be sometimes aggregated together. It is of a greenish yellow, and gives the general colour

Digitized by Google

to the rock. The larger grains show a slight pleochroism. The epidote can be distinguished from the other constituents of the rock by its high refractive index and strong double refraction; it appears to form the greater bulk of the rock, and inclusions of it occur in some of the larger felspar grains. Chlorite exists in considerable abundance in the form of flakes, and is of a light green colour; usually the pleochroism is not very strong, but in other cases it gives well-marked green and brown tints. The larger pebbles of quartz and felspar are generally surrounded by a mosaic of granular material, the felspars often showing turbid centres. In several instances the twinning bars of the felspars can be detected in the undeformed portions of the grains. In other cases the pebble has evidently been crushed from rim to centre, the existence of the sand-grain being indicated by aggregations of granules of quartz or felspar. Under crossed nicols a system of strain shadows may be seen in several of the uncrushed felspars. Biotite occurs abundantly in most of the beds, with distinct cleavage and strong pleochroism, in reddish brown and yellow tints. The quartz, like the felspar, has generally become more or less broken down, and now appears aggregated together in lenticular-shaped areas, round which the flakes of biotite and chlorite are arranged, giving the rock a more or less well developed "augenstructur."

Immediately to the north of Ardlui Station there is a considerable cutting in the railway, and the rocks there have been identified by the Survey Officers as belonging to the "Green Beds." They will at once strike the observer as being in a much higher state of metamorphism than those above described, as they now exist as dark hornblende schists which would at once be considered to be an altered basic rock. According to the Survey, however, many of the hornblende schists near the great axial line of folding, and evidently upon the same horizon as the "Green Beds," are simply the same in a more advanced state of metamorphism, the chlorite having passed into hornblende. A number of more gritty bands, intercalated with the hornblende schists, have become quartz epidote schists with hornblende and felspar, or an albite gneiss with chlorite and hornblende. It would be difficult to speak definitely as to the original character of the "Green Beds" and the conditions under which they were deposited. They are clearly

Digitized by Google

of clastic origin, and though they have now become almost wholly crystalline, the broken and shattered quartz and felspar grains may represent part of the original sediment. The other minerals may be looked upon as of secondary origin.

The paper was illustrated by a series of maps, by specimens of the rocks spoken of, and by slides from photographs shown by the oxyhydrogen lantern.

Digitized by Google

No. XXX.—A Theory of the Origin of Columnar Structure as Illustrative of Sections near Glasgow. By John Wallace.

[Read 11th December, 1902.]

(Summary.)

In the course of his remarks the author stated that many different observers had advanced theories and speculations as to the origin of the curious rock-appearances known as columnar structure—Dana, Daubeny, Prestwich, Scrope, Mallet, Thomson, Bonny, and others—and quoted at more or less length their various conclusions. These might, however, be all shortly summed up in the manner adopted by Professor James Thomson, of the University of Glasgow, who, in a paper read before the Society in 1877, and printed in the *Transactions*,* stated that they were due to one or other of the following forces:—1st. Prismatic fracture by shrinkage in cooling, like the cracking which may be observed in starch or in drying mud. 2nd. An assumed spheroidal concretionary action of the lava or basalt in solidifying from its molten state. Some other causes than either of these given by Professor Thomson must be found, though prismatic structure might be accounted for by shrinkage in cooling. As regards the second or concretionary theory, it is by no means sufficient to account for the various wonderful forms which may be seen at various localities, such, for instance, as bent columns; or those found lying at all angles, as at Dunglass Hill; or those radiating like the spokes of a wheel, like the well-known Spindle Rock at St. Andrews. The author's own idea, briefly stated, was that the structure was caused by the action of gaseous vapours working to the surface from below, along the lines of least resistance, by a series of bubbles or gas-filled cavities, which in some way carried the eruptive material along with them. These gas-bearing receptacles impinging one on another with

* "On the Jointed Prismatic Structure in Basaltic Rocks," *Trans.*, vol. vii., part 1, 1882, page 85.

Digitized by Google

mutual pressure would induce lines of weakness, along which the molten mass, when finally sufficiently cooled, would begin to develop cracks or partings. Probably the lava would thus only be acted upon at a certain stage of consistency, and by those kinds of vapours which had sufficient assertive force to act upon the enclosing mass of semi-liquid material. He thought that the cross-jointing so often observed in the columns, and the ball or spheroidal appearances to be seen in weathered examples of eruptive rock, might be due to similar forces of vapours, which had imparted a kind of circular form with concentric joints along which the weathering action could most easily have effect, though the structure itself might not be originally apparent to the eye. Regarding the columnar structure sometimes found in sandstone, as in Bute, the writer did not give a definite opinion, but he drew attention in this connection to the paper read before the Society in 1873 by the late Mr. D. C. Glen, and printed in the *Transactions*,* where the action of steam or other heated vapours was given as a possible reason for its formation in sandstone.

In conclusion, Mr. Wallace said that, though he brought up these points for consideration at the present time, they might not be looked upon as in all ways affording a feasible theory to account for the phenomena of columnar structure. He was, however, in hopes that they would at least help some more experienced student than himself to arrive at a satisfactory conclusion regarding them.

The paper was illustrated by diagrams, specimens of rocks, and photographs thrown on the screen by the oxyhydrogen lantern.

* "On a Tract of Columnar Sandstone near Kilchattan, Bute"; *Trans.*, vol. v., part 1, 1877, page 154.

Digitized by Google

No. XXXI.—The Origin of Granite. By James Anderson.

[Read 8th January, 1903.]

(Summary.)

The author in the first instance contested the generally-accepted theory that granite is of plutonic origin, or, in other words, part of the molten or plastic magma which occupies the interior of the Earth. After referring to the evidences offered in support of this theory, such as the alteration on neighbouring rocks and the arms of granite which penetrate surrounding strata, he pointed out that the great mass of granite in Arran must have reached at one time such an altitude, that had it either been molten or plastic it would have spread itself over the whole island, and filled up Kilbrannan Sound. Its elevation can still be approximately estimated from the rising tangents of the sides of the existing mass. The angle of dip is well seen at several points where it rises not far from the perpendicular, and, prolonging that rise afterwards at a gradually lessening angle, a cone nearly as high as the whole length of Arran would be the result. Without assuming that a perfect cone was ever formed, it is certain that the granite formed an immense mountain before denudation began to wear it down, and that it would not have held together if it had been plastic in the slightest degree.

To arrive at a reasonable view of the origin of granite, it is necessary to begin at a very early stage of the Earth's history. Sir Robert Ball in his latest work, "The Earth's Beginning," attributes the origin of our planet to a circling eddy in a nebula, leaving it to be supposed that this circling went on until it assumed the condition of a molten globe. He does not say that the material forming the nebula was in a molten state, nor does he explain how and when it began to melt. This molten globe figures largely in the works of geological writers, ancient and modern. Sir Archibald Geikie's recently published work on "The Ancient Volcanoes of Great Britain" is entirely based on the

Digitized by Google

assumption that all active volcanoes have been, and are, fed from the interior molten magma. It may be asked, if that is the case, why is there any difference between granite and any other volcanic product? While providing every volcano with an opening to the seething mass below, Sir Archibald apparently forgets that such an arrangement would not in reality be practicable. The central magma cannot be conceived of otherwise than as a homogenous mass without any divisions, and any tendency to expansion at one corner would spread itself through the whole. If, let us say for argument's sake, an explosive condition could be generated in the molten magma of the interior (and Sir Archibald's theory is that all volcanoes are connected with, and supplied from, this magma), then we should have every volcanic opening on the Earth's surface in active eruption at the same moment. He seems also not to have taken into account that an explosion chamber is a first necessity in the economy of a volcano, just as it is in the case of a gun, and one that could not be provided by the magma, whether molten or plastic.

To keep a volcano in activity, an explosion chamber must be surrounded by substantial rock-walls on all sides. What may be the exact force in operation is an open question, and cannot be dogmatised about, but the suggestion may now be offered that chloritic strata undergoing metamorphism may reach an explosive condition in the course of time. Even more cogent reasons might be given why volcanoes cannot possibly be fed from the central mass of the earth, whatever its condition. The density of its crust is, roughly speaking, only one-third of that of the mass it encloses; therefore the latter would not attempt to rise, even if the crust was perforated all over or reduced to fragments, because the lighter superincumbent mass could not possibly sink into the denser material below.

After discussing the present state of certain of the planetary bodies and pointing out their bearings upon the problem, the author then proceeded to discuss the relationships between granite and the primitive schists, and said, assuming there is a doubt that the foliation of these primitive beds is due to the shrinkage of the Earth, it is at least certain that they are wonderfully different now from their original condition. As they exist they would suffer complete disruption if forced to bend to the slightest

Digitized by Google

extent. But their foliation shows that they once were as pliable as so many layers, or thicknesses, of cloth. It is further evident, from the unbroken continuity of the bedding throughout each and every fold, that they must have possessed a considerable degree of tenacity and some sort of matted or felted form.

It is impossible now to determine whether the Earth's granitic areas suffered to any extent in the general shrinkage. The material on which the schists rested would yield, and the bosses of granite would thereby be brought to a lower level, but there is not much evidence of crushing having taken place within the masses of granite themselves. The evidence afforded by the existing conditions and the positions of all classes of rock in near contact with granite, shows that the movement of displacement was caused by the sliding downwards of these surrounding rocks while the granite remained passive. Where recent volcanic eruptions have occurred, the enclosing rocks do not show the destructive shattering shown by those which border the granite. The same holds good with all great faults, and it has always been the rock which moved that suffered damage.

Digitized by Google

No. XXXII.—Notes on the Geology and Archæology of Syria and Palestine. By James Neilson, Milnbank.

[Read 12th March, 1903.]

(Summary.)

Travelling from Cairo in Egypt, *via* Port Said, the author landed in Beyrout. Of the mountains of Lebanon he remarked that, although they reached an altitude of nearly 10,000 feet, they were new, compared with our own Grampians, or even the Stirlingshire or Renfrewshire Hills, some of their rocks containing fossil fish of Tertiary age. He had been deeply impressed by the beauty and magnitude of the ruins of Baalbec, and the carving was magnificent. Some of the stones in the Temple buildings were so large that the question arose as to the appliances used for getting them into position. Three, known as "trilithons," are supposed to be the largest stones ever used for building purposes, their weight being computed at 770 tons each. They are built into one of the walls, and their bases are over 20 feet above the ground. One still larger, but never removed from the quarry, about half a mile distant, is said by Baedeker to weigh about 1500 tons, but the author thought 900 would be nearer the reality. From this to Damascus, through Anti-Lebanon, the railway passes along several deep, narrow gorges, where great contortions and faultings in the light-coloured, thin-bedded limestones were noticed. Taking steamer from Beyrout, a call was made at Saida (the ancient Sidon), apparently a prosperous little place, while Tyre (passed in the night) seemed much less thriving.

Landing at Haifa, at the foot of Mount Carmel a great ridge of Cretaceous limestone, about 1700 feet high, which from a distance bears some resemblance to our Campsie Hills, the same formation was found to continue all the way through Nazareth and Cana of Galilee to Tiberias, where its junction with the volcanic rocks could be seen. These latter are mostly hard black basalt with occasional small crystal-lined cavities. Many of the

Digitized by Google

watercourses here run underground and suddenly emerge as large surface springs—"fountains of living water"—some giving off as much water as, say, the Cart at Cathcart, and those entering the Sea of Galilee are often quite salt. The temperature of those near the junction of the limestone and the basalt is warm or hot, and those used for the baths at Tiberias are over 140° Fahr., and very salt. The salt constantly pouring into the lake, and which has been carried down the Jordan, and thence into the Dead Sea for thousands of years, may be the cause of the saltness of that singular sheet of water.

A remarkable circumstance is that while the Sea of Galilee is freshwater, yet by far the greater number of the molluscs, which inhabit it abundantly, are of marine type, and the commonest —a *Nassa* like our home species—can be picked up in hundreds, either alive or dead. Altogether Mr. Neilson had found about 16 species of univalves, all marine in type, and belonging to the following genera:—*Strombus*, *Conus*, *Natica*, *Chemnitzia*, *Trochus*, *Bulla;* with three bivalves, *Mactra*, *Venus*, and *Petunculus*. Several of those were identical with those found on the Haifa beach. Near the mouth of the Jordan there were many valves of a small *Unio*, probably of freshwater origin, and there were also a good many crabs. The occurrence of the salt springs and the organisms of marine type raises some important questions. First, these salt springs, representing underground rivers, may be derived from the sea, the water of which, percolating through the rocky joints and fissures, widened by chemical and mechanical action, had eventually forced their way by gravitation to the valley bounding this lake, 30 miles from the sea, and 680 feet below its level. The eggs and larvæ of the marine organisms passing through with the water may have been discharged in a living state, finding shelter until sufficiently acclimatised. Or, secondly, they may have come when the land stood at least 250 feet lower than it is now. This valley would then be connected with the Mediterranean over the plains of Esdraelon, but as the land gradually rose, the connection with the sea would be cut off, and the waters, reduced by evaporation, would gradually subside, the salt being forced lower—*i.e.*, southward—by the continued influx of fresh water from the north, till the present conditions gradually evolved themselves. Thus there would be time for the

Digitized by Google

organisms to adapt themselves to their new surroundings. Geologically speaking, this rise of the land may have taken place at a comparatively recent period.

Through the plains of Sharon and Philistina to Jerusalem, Bethlehem, the Dead Sea, and Jordan, and to Jericho, the route was further graphically described.

The lecture was illustrated by a series of photographs by the author, mostly taken in Palestine, which were thrown on the screen by the oxyhydrogen lantern.

Digitized by Google

PROCEEDINGS FOR SESSION 1901-1902.

(44TH SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET, 23RD OCTOBER, 1901.

Bailie WILLIAM MACLAY, *Vice-President*, in the Chair.

The HONORARY SECRETARY (Mr. Murdoch) read a communication he had received from Mr. John Wight, C.A., who had held the post of Honorary Treasurer to the Society for the last 33 years, having been first appointed to it in 1868. Mr. Wight stated in his letter that, owing to his advancing years, and consequent inability to attend evening meetings, he wished respectfully to resign the Treasurership as from the ensuing November meeting. The announcement was received with great regret by the members present.

Mr. GOODCHILD, F.G.S., of the Geological Survey, and Curator of the Collections of Scottish Geology and Mineralogy in the Museum of Science and Art, Edinburgh, gave the Opening Address for the session, the subject being "The Lower Carboniferous Rocks of Northern Britain."

[Printed in full in the previous part, see *Transactions*, vol. xii., part 1, 1902, page 16.]

The paper was illustrated by an extensive series of photographs and diagrams, thrown on the screen by the oxyhydrogen lantern.

Remarks were made afterwards on various points in it by Mr. JAMES NEILSON (1), Mr. PETER MACNAIR, and other members.

SOCIETY'S ROOMS, 207 BATH STREET, 14TH NOVEMBER, 1901.

THE ANNUAL GENERAL BUSINESS MEETING.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

The HONORARY SECRETARY (Mr. James Barclay Murdoch), read as follows :—

THE REPORT OF THE COUNCIL FOR 1900-1901.

The Council beg to submit to the members their Report upon the work and progress of the Society during the past year—the forty-third of its existence.

Digitized by Google

The MEMBERSHIP has just about retained its level, and the increase hoped for not having taken place there is still room for effort in this direction.

The ASSOCIATE MEMBERSHIP rather increased, and, as it is a feeder to the Society, further enrolment of young and student associates is desirable.

The FINANCES, which will be reported upon by your Hon. Treasurer (Mr. Wight), are in a sound and healthy condition.

The LIBRARY work has been fairly active, the circulation of books being considerable, as will be seen from the Report submitted by Mr. M'Lennan, the Hon. Librarian.

The MEETINGS of the session were nine in number, extending from October to the end of May, and were generally well attended, some largely so. A number of valuable and interesting papers were read and discussed, and a variety of specimens exhibited, some with accompanying notes.

The EXCURSIONS.—During the year there were nine Excursions—three day and six afternoon—with five Evening Excursions, most of the latter being to the Glasgow International Exhibition, where the rock and mineral collections contributed by the Colonies were found to be of great interest. (See Excursions for the Season of 1901, page 261.)

The TRANSACTIONS.—Part 2 of vol. xi., with index to the volume, was issued to members during the session. A new part will, it is hoped, be ready for issue early in the new year.

EVENTS OF THE YEAR.—The Jubilee of the University of Glasgow—being the five hundredth anniversary of its foundation—occurred in June, 1901, and was celebrated by a great gathering of scientific and distinguished men from all parts of the world to do honour to our ancient *Alma Mater*. The Society was represented by the Honorary Secretary, Mr. Murdoch, who had been chosen as its delegate.

THE BRITISH ASSOCIATION MEETING for 1901 was held in Glasgow in September, and was very successful, although the members attending were fewer than had been expected, a result probably caused by the extraordinary number of meetings and gatherings of every kind which had been held in the City within a few months, not to speak of the counter-attractions of the Glasgow International Exhibition itself. Many of our members contributed articles to a "Handbook on the Natural History of Glasgow and the West of Scotland," compiled for the British Association Meeting, and the Council hope that the geological portion of this book will continue to serve as a local guide for many years to come, like its predecessor, issued for the Meeting of 1876.

SCOTTISH ANTARCTIC EXPEDITION.—Mr. William S. Bruce, leader of the Expedition, kindly agreed to address the members on the subject of his voyage, and gave, on 31st January, 1901, a most interesting lecture on his aims and intentions.

Digitized by Google

The LOSS OF MEMBERS and Friends of the Society during this year has been severe. In February, 1901, the death took place of Mr. James Bennie and of Mr. Robert Craig, both of whom had been actively connected with the Society for many years. And in the following May, Mr. James White, who had been its Hon. Librarian and an active contributing member for a very long period, was also removed from among us. As notices of each of the deceased gentlemen were read at meetings of the Society, more need not now be said than a renewal of the expression of profound regret by the Council at the loss sustained by the Society through the death of these attached friends.

The HONORARY TREASURER (Mr. John Wight, C.A.), submitted his Financial Statement. [For an Abstract of Accounts see page 271.]

The HONORARY LIBRARIAN (Mr. J. S. M'Lennan) read his Report on the work of the Library during the year.

The various Reports showed the affairs of the Society to be in a thriving condition, and, on the motion of the Chairman, they were unanimously approved. A hearty vote of thanks was also awarded to the standing officials for the trouble and care they had expended in the conduct of the Society's business.

To fill the vacancies in the Council occurring at this time the following members were declared duly elected:—As Vice-President, Mr. James Stark; as Members of Council, Bailie Maclay, Messrs. James Neilson (1), James Neilson (2), and David Chalmers—all for three years.

Messrs. J. R. M'Farlane and David Pearson were re-elected Auditors for the current year.

Mr. William M. Gale, C.E., Corporation Waterworks, 18 Huntly Gardens, Kelvinside; Rev. J. D. M'Culloch, Congregational Manse, Galston; and Mr. E. Hall Wight, 150 Hope Street, were elected Ordinary Members of the Society.

A model of the western end of the Campsie Hills, including Ballagan Glen, made by Mr. A. L. du Toit, was exhibited by him, and he gave some interesting particulars of the methods used in its construction. He had presented it to the Hunterian Museum of the University of Glasgow.

A paper on "Ore Deposits, and how they are formed," was read by Mr. GEORGE R. THOMSON, Lecturer in the Technical College, Glasgow [who had been recently appointed Professor of Geology in the Yorkshire College, Leeds]. In the course of his remarks he reviewed the various theories put forward to account for the formation of metalliferous veins, and gave a most interesting account of the different mining methods in use for their extraction, both in this country and abroad.

In illustration of the paper a large number of diagrams and photographs were projected on the screen by the aid of the oxyhydrogen lantern.

Some observations on various points mentioned in the paper were made by members.

Digitized by Google

SOCIETY'S ROOMS, 207 BATH STREET, 12TH DECEMBER, 1901.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

The HONORARY SECRETARY (Mr. Murdoch) stated that, as a vacancy had been created in the Council at the November meeting by the election of Mr. James Stark to the Vice-Presidentship, the Council had appointed Mr. William Sinclair to fill the post for the unexpired term of two years.

Mr. James Hunter, Townhead Public School, Kirkintilloch; Mr. George Howie, Clydeside Cottage, Uddingston; Mr. Wm. Petrie, 6 Willowbank Crescent; Mr. William Reid, 2 Firpark Terrace; Mr. Thomas J. Richards, 11 Wilton Mansions; Mr. Richard Sneddon, 73 Pitt Street, Newton, Cambuslang; and Mr. Andrew Stewart, Landsland School, Kirkintilloch; were elected Ordinary Members of the Society.

Mr. W. E. Manson, 12 Regent Park Terrace; Mr. Vere E. Moore, M.E., 52 Albert Drive, Crosshill; and Mr. Roland E. Muirhead, Winona, Bridge of Weir; were elected Associate Members.

An appreciative obituary notice of the late Bailie JOHN FARQUHAR, long a member and office-bearer of the Society, was read by Mr. WILLIAM JOLLY, F.G.S. The deceased gentleman had been an active member of the Corporation of Glasgow, and had greatly interested himself in the housing of the poor and other philanthropic projects in the City. Though never taking an active part in the work of the Society, he had always kept up his interest in it, and had at one time presented the members with a valuable Microscope, which had ever since proved of great service. The Chairman (Mr. Blair), the Hon. Secretary (Mr. Murdoch), Mr. James Steel, Mr. Joseph Sommerville, and Mr. Peter Macnair, also spoke of their remembrances of Bailie Farquhar, and a motion of condolence with his widow and family was unanimously passed.

A paper entitled "Notes on the Geology of the Mediterranean Seaboard" was read by Mr. JAMES STARK, Vice-President. (See page 159.)

The paper was illustrated by maps and diagrams and by a large number of geological specimens.

Remarks on various points in the paper were made by Mr. James Neilson (1), Mr. William Jolly, F.G.S., and the Chairman (Mr. Matthew Blair).

The CHAIRMAN (Mr. Blair) reported for himself and Mr. Murdoch (Hon. Secretary) that, having been appointed delegates to represent the Society at the celebration of the Jubilee of the Natural History Society of Glasgow, they had been present at the Conversazione held for the occasion on the 4th instant, in the Masonic Hall, West Regent Street, under the chairmanship of Mr. Alexander Somerville, F.L.S., President of the Society, that it had been largely attended by the members and their friends, also by representatives of other scientific bodies, and that it had been quite a success.

Digitized by Google

SOCIETY'S ROOMS, 207 BATH STREET, 9TH JANUARY, 1902.

Mr. JAMES STARK, *Vice-President*, in the Chair.

On the motion of Mr. JOSEPH SOMMERVILLE, a sum not exceeding £10 of the Society's funds was unanimously voted for the use of the Library during the current year.

The HON. SECRETARY (Mr. Murdoch) announced that the palæontological collection of the late Mr. James Dairon, for many years an active member of the Society, who had worked so largely among the Lanarkshire Graptolites, had just been presented to the Corporation Museum by Mrs. Fleming his daughter, and her husband. It was fortunate that the City had come into possession of such a fine local collection of fossils, and one so much identified with the Society itself.

Mr. J. Graham Callander, F.S.A.Scot., 20 Rupert Street; Mr. John F. Campbell, 15 Montgomerie Crescent, North Kelvinside; Mr. Alex. L. du Toit, 26 Newton Street; Mr. William Kemp, 1 Doune Quadrant, Kelvinside; Mr. Daniel Jackson, Thornbank, Dumbarton; and Mr. William Leighton, 120 Hope Street; were elected Ordinary Members of the Society.

Mr. Drummond Callander, 20 Rupert Street; Mr. William Harvey Carron, C.E., 207 St. Andrew's Road, Pollokshields; and Mr. Donald F. Forbes, 186 Henderson Street; were elected Associate Members.

A paper on "The More Important Groups of Carboniferous Plants—1st part—Ferns, *Equisetites* and *Calamites*," was read by Mr. ROBERT KIDSTON, F.R.S.L. & E., F.G.S., Vice-President. After dealing with the dichotomy, fructification, and general aspects of recent Ferns, the author described in detail the principal characters of the leading genera of Carboniferous Ferns, including *Pecopteris*, *Alethopteris*, *Neuropteris*, *Sphenopteris*, and others. He pointed out that while in many instances the fruit of these different groups had been found in actual organic union, there was still a number of fern-like plant-remains, the exact affinities of which could not at present be definitely ascertained, and which were placed in a special group—the Cycadofilices. Proceeding next to deal with the *Equisetites*, Mr. Kidston selected as a type of the group *E. Hemingwayi*, cones of which have been found in the Carboniferous rocks of Yorkshire. He compared the fossil cone with that of the recent *E. liniosum*, showing how closely they agreed in their external features, and that therefore it was evident the genus had been represented by close allies from Carboniferous times. Lastly, he dealt with the *Calamites*, showing that their well-known ribbed appearance was really only a cast of their pith-cavity.

The paper was illustrated by a large and representative series of photographs and drawings, thrown on the screen by the oxyhydrogen lantern.

At its close remarks were made on the subject by Mr. Peter Macnair, Mr. Joseph Sommerville, and the Chairman (Mr. Stark).

Digitized by Google

SOCIETY'S ROOMS, 207 BATH STREET, 13TH FEBRUARY, 1902.

Mr. ROBERT KIDSTON, F.G.S., *Vice-President*, in the Chair.

Mr. Matthew Blackwood, Ardmore, Port-Glasgow; Mr. John M. Cairncross, M.E., Murray Place, Strathbungo; Mr. T. Lindsay Galloway, C.E., Mair Street; and Mr. Alexander M'Lean, St. George's Road; were elected Ordinary Members of the Society.

The CHAIRMAN referred to the loss which the Society had recently sustained in the death of Mr. J. R. M'Farlane, who had for a number of years taken a great interest in its work, and was one of the auditors for the current year.

Mr. WILLIAM YOUNG, R.S.W. (as an intimate friend), spoke in feeling terms of Mr. M'Farlane's fine qualities.

Mr. R. W. DRON, C.E., M.E., exhibited a series of specimens of stones, branches of trees, &c., from the Linn of Baldernock, which were covered with an incrustation of lime, and made some remarks on their bearings on the subject of fossilisation.

By a diagram Mr. Dron also showed the lateral displacement of an intrusive dyke of dolerite by faulting, and spoke of the importance of a careful examination of the courses taken by such dykes. They often gave evidence of the existence of faulting which could not be otherwise detected. In cases where the intrusive rock had come in contact with a bed of coal the latter had been considerably altered, charred, and burnt.

Mr. JAMES S. M'LENNAN, Hon. Librarian, read a paper entitled "A Stroll along a Trap Dyke in the Parish of Beith, Ayrshire." (See page 214.)

The paper was illustrated by the Geological Survey Map, No. 22, on the 1-inch scale.

Mr. ALEX. L. DU TOIT read a paper on some "Fresh Points in the Structure of *Apiocrinus*." (See page 187.)

The paper was illustrated by a large series of photographs and diagrams thrown on the screen by the oxyhydrogen lantern.

Mr. PETER MACNAIR read a paper on "A Plutonic Complex at Tomnadashan, Loch Tay, Perthshire." He first described in some detail the general geological structure of the area in the vicinity of the complex, showing that the crystalline schists of the Highlands had been there invaded by a boss of plutonic rock, which had produced a large amount of contact metamorphism upon the surrounding schists, these being penetrated and hardened by apophyses from the main intrusion. He then showed that the complex consisted of two distinct types of rock, one acid, the other basic, in character. The first-named was a variety of granite, and the latter showed affinities with the kersantites or mica diorites. Many years ago Ordernheimer said these two widely distinct types had been segregated out from the same rock-magma, though this view had been afterwards departed from in favour of the theory that they repre-

Digitized by Google

sented separate and distinct intrusions. The original view is now, however, gaining ground again, Messrs. Dakyns and Teall having advanced similar reasons to those of Ordernheimer to account for the plutonic complex at the head of Loch Lomond.

Mr. MACNAIR also gave a Report upon an Excursion made by the Society last year to Creag na Caillich, a mountain near Killin. (See Excursions for the Season of 1901, page 261.)

Some remarks on the district were afterwards made by Mr. William Young, R.S.W., Mr. A. L. du Toit, and Mr. Matthew Blair, V.P.

SOCIETY'S ROOMS, 207 BATH STREET, 13TH MARCH, 1902.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

Mr. John Dewar, 132 Main Street, was elected an Ordinary Member of the Society.

Dr. B. N. PEACH, F.G.S., of H.M. Geological Survey, read a paper on "The Cambrian Fauna of the North-west Highlands." (For a Summary see page 223.)

SOCIETY'S ROOMS, 207 BATH STREET, 10TH APRIL, 1902.

Mr. JAMES STARK, *Vice-President*, in the Chair.

Dr. R. H. TRAQUAIR, LL.D., F.R.S., Keeper of the Natural History Collections in the Museum of Science and Art, Edinburgh, gave a Lecture on "The Vertebrate Animals of the Coal Period." (For a Summary see page 224.)

The paper was illustrated by a large series of diagrams and photographs thrown on the screen by the oxyhydrogen lantern.

Mr. PETER MACNAIR exhibited a number of lantern slides of photographs of the section exposed in the excavations for the new Pumping Station of the Glasgow Main Drainage Works in Dumbarton Road, made by Mr. S. Fingland and Mr. William Sinclair. (See Excursions for the Season of 1902, page 265.)

SOCIETY'S ROOMS, 207 BATH STREET, 8TH MAY, 1902.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

Mr. Henry Watson, Shipowner, 8 Victoria Crescent, Dowanhill, was elected an Ordinary Member of the Society.

Mr. JAMES ANDERSON read a paper entitled "Antarctic Speculation." (See page 167.)

Captain ROBERTSON, formerly in charge of the Discovery Ship "Heckla," and now of the Scottish Antarctic Expedition, brought forward a large series of photographs and views descriptive of natural conditions in the

Digitized by Google

Arctic and Antarctic regions, some being thrown on the screen by the oxyhydrogen lantern, and gave a graphic and highly interesting account of his experiences when on different whaling expeditions in those seas.

Remarks were made afterwards by Mr. William Jolly, F.G.S.; Mr. James Neilson (1), and other members.

SOCIETY'S ROOMS, 207 BATH STREET, 29TH MAY, 1902.

Mr. JOHN RENWICK, *Vice-President*, in the Chair.

Mr. H. W. Andrews, 128 Hope Street, was elected an Ordinary Member of the Society.

Mr. MATTHEW BLAIR read a paper on "The Physical Geography and Geology of Egypt." (See page 173.)

Mr. JAMES NEILSON (Milnbank) read a paper entitled "Notes on a Recent Trip to Egypt." (For a Summary see page 226.)

The paper was illustrated by a large series of photographs and diagrams thrown on the screen by the oxyhydrogen lantern, also a collection of fossils, and stone and flint implements.

Remarks were afterwards made by Rev. J. E. Sommerville, and Mr. William Jolly, F.G.S.

SOCIETY'S ROOMS, 207 BATH STREET, 11TH JUNE, 1902.

Mr. JAMES STARK, *Vice-President*, in the Chair.

Mr. James Spencer, jun., was elected an Ordinary Member of the Society.

Mr. JOHN RENWICK exhibited a specimen of the Volcanic Dust which fell at Barbadoes on 7th May last, and made some remarks upon its occurrence.

Mr. A. L. DU TOIT exhibited, under the Society's Microscope, a series of Slides of similar Barbadoes Volcanic Dust. Light grey in colour, it consists, when seen under the microscope, of rounded and irregular grains, and crystals often well formed. The average diameter of these particles varied from 1-50th to 1-150th of an inch. Their constituents are as follows:—Plagioclase, clear, colourless, occasionally showing under polarised light the characteristic lamellar twinning. This is nearly always in irregular fragments, very commonly showing zoning, bubbles, negative crystals, and enclosures of brownish material. Felspar, ranging from oligoclase to Labradorite. Quartz is possibly present. Hypersthene is present in fair amount, often in well-developed crystals, yellowish to brownish coloured, and prismatic in habit. The pleochroism is strongly marked. Augite is present in small amount, in irregular fragments, yellowish-green in colour. Neither biotite, olivine, nor hornblende is present, but a small amount of yellowish to brownish-coloured glassy material, containing blackish dusty matter, with sometimes elongated bubbles or flow-structure. Fragments of opaque brownish matter are present in quantity.

Digitized by Google

The following Analysis and Report were prepared from the same specimen by Mr. J. C. Galletly, Assistant Lecturer on Metallurgy in the Technical College:—Silica, 51·31; alumina, 24·64; ferric oxide, 8·74; manganese oxide, none; lime, 10·63; magnesia, 3·86; alkalies, chiefly soda, not determined; moisture, 0·36—Total, 99·54. By spectroscopic examination there was no indication of the presence of heavy metals. The ash is basic in character, and seems to have been derived from a lava having the composition of a basaltic andesite, or a basalt. Somewhat noteworthy is the small amount of glassy material present; while, again, the presence of hypersthene is interesting. The nearest approach to this among Scottish rocks are the andesitic lavas and tuffs of Lower Old Red Sandstone age found in the Cheviots, which have an orthorhombic pyroxene (hypersthene) present, in addition to augite and magnetite.

The Hon. Secretary (Mr. Murdoch) read on behalf of the author, Mr. William Gunn, F.G.S., of H.M. Geological Survey, a paper (which from illness the author was not able to read in person) "On a Volcanic Series associated with the Schists of North Glen Sannox, Arran." (See page 192.)

The paper was illustrated by a number of photographs, a sketch map of the district, and rock-specimens.

Further remarks on the subject were made by Mr. A. L. du Toit and Mr. Peter Macnair.

Reports on some recent Excursions of the Society were read by their respective Conductors as follows (see Excursions for the Season of 1902, page 265):—

On 15th February.—To the Pumping Station of the Glasgow Main Drainage Works, Dumbarton Road. By Mr. David Chalmers.

On 15th March.—To the New Dock at Yoker, Dumbartonshire. By Mr. Joseph Sommerville.

On 12th April.—To the New Branch Railway, Johnstone to Dalry, G. & S. W. Ry., Ayrshire. By Mr. John Smith.

10th May.—To Cleghorn and Cartland Crags, Lanarkshire. By Mr. James Stark, V.P.

On 22nd May.—To Dunbar, East Lothian. By Mr. J. G. Goodchild, F.G.S.

The Chairman (Mr. James Stark, Vice-President), then declared the forty-fourth session to be closed, expressing a hope that all the members present would be able to meet again next October in health and strength.

Digitized by Google

PROCEEDINGS FOR SESSION 1902-1903.

(45TH SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET, 9TH OCTOBER, 1902.

Mr. MATTHEW BLAIR, *Vice-President*, in the Chair.

The HON. SECRETARY (Mr. Murdoch) gave some particulars of an Excursion proposed for Saturday, 18th instant, when the members were invited to visit the site of the Roman Camp near Castlecary, on the line of the Roman Wall, where for some time excavations had been carried on under the supervision of a Committee of the Society of Antiquaries of Scotland. The party would be conducted over the ground by Mr. George Macdonald, F.S.A.Scot., a member of the Excavation Committee.

Mr. William Jolly, F.G.S., and Mr. John Smith made some remarks on the present and previous excavations on the line of the Roman Wall and its Forts.

Mr. GOODCHILD, F.G.S., of H.M. Geological Survey, gave an Address, the subject being "Volcanoes: their Causes and Effects." (For a Summary see page 228.)

It was illustrated by a fine series of photographs, some taken by Dr. Tempest Anderson, which were thrown on the screen by the oxyhydrogen lantern.

SOCIETY'S ROOMS, 207 BATH STREET, 14TH NOVEMBER, 1902.

THE ANNUAL GENERAL BUSINESS MEETING.

Mr. ROBERT KIDSTON, F.R.S., F.G.S., in the Chair.

The HON. SECRETARY (Mr. James Barclay Murdoch) read as follows:—

THE REPORT OF THE COUNCIL FOR 1901-1902.

The Council have the pleasure of submitting their Report for the year ending 30th September, 1902.

The MEMBERSHIP has slightly increased this year, though not nearly to the desired extent. The Council believe they are justified in saying that a city so large and so populous as Glasgow, in which so many of its people are interested in industries connected with minerals, metals and other earth-products, should be able to contribute a few hundred more members to the roll of their local geological society than it at present contains. The very moderate annual subscription, or that for life membership, cannot possibly stand in the way, as they are not nearly proportionate

Digitized by Google

to the return given in the form of Meetings, Excursions, Use of the Library, &c. The only alternative supposition is that the advantages offered by the Society are not sufficiently known to the general public. The Council would therefore again urge upon members to interest their friends, and propose them for early election.

The FINANCES, which will be reported on by the Hon. Treasurer (Mr. Hall Wight), are in a favourable condition, though of course the income, from the reason alluded to in the previous paragraph, is not so large as could be wished.

The LIBRARY continues to be made use of to a considerable extent. Here, too, if the income were larger many useful additions could be made to the Collection with great advantage to the members.

The MEETINGS of the Session, eleven in number, were held from October to June, the last an extra one. In spite of many outside attractions the attendance was good, sometimes large.

The PAPERS brought forward at the meetings were thirteen in all, and also a number of Reports of Excursions were submitted by their various conductors. Some of these papers have been printed in the *Transactions* either in full or in abstract. Many when read were illustrated by maps, diagrams, and specimens, and almost always by photographs thrown on the screen by the oxyhydrogen Lantern. In this latter connection the thanks of the members are due in no small measure to Mr. F. Martin, Keeper of the Rooms, 207 Bath Street, for his careful and intelligent manipulation of the Lantern, a matter of no small moment to speakers, who are always somewhat dependent on a successful presentment of their slides.

SPECIMENS, accompanied by Notes more or less extensive, were exhibited at many of the meetings, and the Council welcome these as a means of introducing the younger members to the work of the Society.

The EXCURSIONS of the year were twelve in number, eight afternoon and two full-day outings. Two were taken jointly with the Edinburgh Geological Society and two with the Natural History Society of Glasgow. There were also three Evening Excursions in May and June, in continuance of an old practice which was found useful to members unable to get away from business on Saturdays. Reports of a number of the Excursions were read at subsequent meetings by their respective conductors, to whom thanks are certainly due for the time and trouble they have expended on behalf of the Society. (See Excursions for the Season of 1902, page 265.)

The TRANSACTIONS.—During the year a new part, vol. xii., part 1, was issued to members, bringing up the Papers and Proceedings to the end of last session. Sheets of a succeeding part are now in the printers' hands.

LOSS OF MEMBERS and Friends of the Society.—During the year occurred the death of Bailie Farquhar, who, though not prominent in the Society's work, had always interested himself in its welfare. Many years ago he presented it with a valuable Microscope, which ever since has proved of great use to the members, especially in connection with the

Digitized by Google

exhibition of specimens at meetings. A notice of the deceased gentleman was read by Mr. William Jolly, F.G.S., on 12th December, 1901.

In February, 1902, the members were startled by the sudden death of Mr. J. R. M'Farlane, one of the Society's auditors, who for many years had been a constant attender of meetings and excursions, and generally interested in the Society's work.

Owing to his appointment to the Chair of Geology in Leeds University College, Mr. G. R. Thompson resigned his position as a member of Council. Since he became connected with the Society Prof. Thompson had been an active working member, and the announcement of his departure from Glasgow was received with general regret.

The HON. TREASURER (Mr. Hall Wight) read his Annual Financial Statement. (For an Abstract see page 272.)

The HON. LIBRARIAN (Mr. James S. M'Lennan) read his Annual Report on the Library.

These Reports were all approved, on the motion of the Chairman, and a vote of thanks was awarded to the standing officials for their work on behalf of the Society.

The following gentlemen were elected to fill the vacancies occurring in the Council at this time—As *President*, Dr. R. H. Traquair, LL.D., F.R.S., Keeper of the Natural History Collections in the Museum of Science and Art, Edinburgh; as *Vice-President*, Mr. James Steel; as *Members of Council*, Mr. James Anderson, Mr. Matthew Blair, and Mr. John Orr—all for a term of three years.

Mr. James Barclay Murdoch and Mr. Peter Macnair were elected *Joint Hon. Secretaries*; Mr. E. Hall Wight, *Hon. Treasurer*; and Mr. J. S. M'Lennan, *Hon. Librarian*—all for a term of three years.

The Hon. Secretary (Mr. Murdoch) stated that Mr. James Neilson, Milnbank, had presented to the Library a copy of the valuable "Fossil Flora" of Lindley and Hutton, in three large 8vo. volumes. He was asked to send Mr. Neilson the Society's thanks for his handsome gift.

Mr. Daniel Burns, M.I.M.E., Lecturer on Mining and Geology in the Technical College, 204 George Street, and Mr. Arthur W. Pridham, 11 Gerrard Street, London, were elected Ordinary Members of the Society.

Mr. PETER MACNAIR exhibited a number of microscopic and macroscopic specimens of the "Green Beds" on Sron Aonaich, and near Ardlui, Argyllshire. (For a Summary of his Remarks see page 231.)

Mr. A. L. DU TOIT read a paper entitled "The Marginal Zone of the Central Highlands in the Loch Lomond-Aberfoyle Area—(*a*) the Highland Rocks; (*b*) the Supposed Ordovician Rocks." At the outset he explained that the tract dealt with extended from Balmaha on Loch Lomond to Aberfoyle, and lay on the north-eastern side of the Great Highland Fault. The beds in that area consist of the Highland rocks, chiefly slates and grits, and a narrow belt of cherts, black shales, and grits, which occur along the line of the Fault, and are very probably of Arenig age, and akin to similar deposits in the South of Scotland. The beds were described in

Digitized by Google

detail, and the results arrived at were—(1) that the Aberfoyle slates are the lowest beds in the region; (2) that the Leny grits are identical with the Ben Ledi grits, and overlie the slates; (3) that the cherts and black shales are unconformable to the Leny grits, and are younger than the latter, though underlying them through inversion and apparently older. The structure, folding, and alteration of the beds by the great forces which acted upon the Central Highlands were also fully described and explained.

The paper was illustrated by maps, specimens of the rocks, and a series of photographs thrown on the screen by the oxyhydrogen lantern.

SOCIETY'S ROOMS, 207 BATH STREET, 11TH DECEMBER, 1902.

MR. JAMES STEEL, *Vice-President*, in the Chair.

Mr. MURDOCH (Joint Hon. Secretary) referred to the recent death of Mr. John Buchanan, who had been a member of the Society for twenty-five years, and a constant attender at its meetings and excursions.

Dr. James Geikie, LL.D., F.R.S., Professor of Geology in the University of Edinburgh; Dr. Charles Lapworth, LL.D., F.R.S., Professor of Geology in the University of Birmingham; Dr. R. H. Traquair, LL.D., F.R.S., of the Museum of Science and Art, Edinburgh; Mr. J. G. Goodchild, F.G.S., F.Z.S., of H.M. Geological Survey; Dr. John Horne, LL.D., F.R.S., of H.M. Geological Survey; and Mr. B. N. Peach, F.R.S., F.G.S., of H.M. Geological Survey, were elected Honorary Members of the Society.

Mr. David Bruce, M.A., LL.D., 141 West George Street; Rev. W. H. Harrower, 2 Beaumont Gate; Mr. James R. Menzies, 6 Woodcroft Terrace, Jordanhill; Mr. Frederick Mort, Viewfield, Partickhill; Mr. Daniel Murray, 220 Gairbraid Street, Maryhill; Mr. James W. Reoch, 22 Montgomerie Street, Kelvinside; Mr. William Sykes, 24 Hamilton Park Terrace, Hillhead; and Mr. Archibald A. Young, 2 Parkgrove Terrace, were elected Ordinary Members of the Society.

Miss Jane Crumlish, 25 Elmbank Crescent, was elected an Associate Member.

The CHAIRMAN exhibited specimens of Retinite in Tertiary Coal from New Zealand; Lignite or Brown Coal from the same country; and the model of a Meteorite which fell near Bugaldi, in New South Wales, with remarks.

Mr. JOHN WALLACE exhibited, on behalf of Mr. Thomas S. Barrie, F.C.S., of the West of Scotland School of Pharmacy, Fragments of a Glass Mortar showing Columnar Structure, and read the following note:—

"This mortar was one of those usually found in any chemist's shop, and a sample of ammonium carbonate had just been reduced to powder in it, water being about to be added to make a solution, when it suddenly fell to pieces. When the thin point of a 'Rupert's Drop' (a tear of unannealed glass) is broken off, the whole is reduced to a myriad of fragments, said to be due to the fact that the glass having been rapidly cooled, the particles

Digitized by Google

have not had time to properly arrange themselves, and are thus in a state of strain. When this strain is released at one point, the release is conveyed to the other portions with the result stated. Though the mortar cannot be said to be unannealed, there may have been a state of strain which the action of the grinding set free. Some of the larger fragments show columnar structure very well. The short columns are hardly ever the same in section at both ends, and are arranged in curves, the others being also curved in many cases, approximately at right angles to those seen in surface-section. May it not be possible that columnar structure in basalts, &c., is due to a similar cause?"

Mr. JAMES STARK, Vice-President, read a paper on "A Tertiary Volcanic Vent in the Island of Arran." (See page 196.)

The paper was illustrated by a series of specimens of the fragmentary rocks found in the vent, volcanic and sedimentary, the latter containing fossils.

At its close an interesting discussion was taken part in by Mr. James Neilson (1), Mr. M. Blair, Mr. P. Macnair, and the author.

Mr. JOHN WALLACE read a paper entitled "A Theory of the Origin of Columnar Structure as illustrative of Sections near Glasgow." (For a Summary see page 234.)

The paper was illustrated by a number of diagrams, a large series of rock-specimens showing columnar structure, and by numerous photographs thrown on the screen by the oxyhydrogen lantern.

A discussion on the subject afterwards took place.

SOCIETY'S ROOMS, 207 BATH STREET, 8TH JANUARY, 1903.

Mr. JAMES STARK, *Vice-President*, in the Chair.

Mr. Ludovic MacLellan Mann, F.S.A. Scot., 142 St. Vincent Street, was elected an Ordinary Member of the Society.

Miss Jane M. Canon, 41 Albert Drive, Crosshill, and Mr. Alex. M'Lean, 466 St. George's Road, were elected Associate Members.

The Hon. Secretary (Mr. Murdoch) announced that, on the recommendation of the Library Committee, the Council had agreed to largely reduce the price of all the remaining copies of the Parts of the Society's *Transactions* up to the end of vol. ix. (the cost of succeeding Parts to remain as published), with the hope of clearing off the remaining stock in hand.

Mr. PETER MACNAIR exhibited macroscopic and microscopic specimens of Grits and Quartzites from the lower and upper arenaceous zones of the Highlands, and made some remarks upon their characteristics. An interesting pebbly grit from the problematical zone seen along the Highland frontier appeared as if many of the pebbles, mostly quartz, had been arranged parallel to the main axis. This might be only accidental; but if the quartz grains were originally derived from

Digitized by Google

bi-pyramidal crystals, they would have a tendency to assume a shape giving low interference colours and uniaxial figures.

Mr. MACNAIR showed some other specimens, including sections of the Ben Ledi grits, the thin fine-grained, white quartzite from the upper argillaceous zone, and others illustrative of the central Highland quartzite or upper arenaceous zone, from Islay, Schiehallion, Falls of Tummel, and Ben-y-gloe. One from Inverness held many garnets.

He also exhibited a pair of right-and-left-handed Carlsbad Crystals of Orthoclase from the granite of Elbogen, Bohemia, figured by Haidinger in his translation of Moh's "Mineralogy," specimens from the collection of the late Professor Fleming of Edinburgh, which had been recently presented to Kelvingrove Museum.

Mr. JAMES ANDERSON read a paper on "The Origin of Granite." (For a Summary see page 236.)

A discussion on some of the points brought up by the author was taken part in by several of the members present.

SOCIETY'S ROOMS, 207 BATH STREET, 12TH FEBRUARY, 1903.

Mr. JAMES STEEL, *Vice-President*, in the Chair.

The JOINT HON. SECRETARY (Mr. Murdoch) called attention to the obituary notice in the "Glasgow Herald" of this date, announcing the death of Mr. Thomas M. Barr, C.E., Willowbank, Perth, who for many years had been the resident engineer of the Northern section of the Caledonian Railway. Mr. Barr was one of the only two surviving Original Members of the Society, his brother, Mr. George M. Barr, who went to New Zealand many years ago, being the other. So long as he resided in Glasgow, Mr. Thomas M. Barr took an active interest in the work of the Society, both in its management and as a contributor of papers, and after his removal to Perth, he always continued to show great interest in its well-being and prosperity. A vote of condolence with Mr. Barr's widow and family was passed, and the Hon. Secretary was instructed to send an extract from the minutes to that effect.

Mr. William Reid, 133 Finlay Drive, Dennistoun; Mr. William Beattie, 3 Broompark Circus, Dennistoun; and Mr. Vere E. Moore, 52 Albert Drive, Crosshill, were elected Ordinary Members of the Society.

Mr. JAMES NEILSON (Milnbank) read a paper on "The Geology of the Clyde Crannogs." (See next part of the *Transactions*, vol. xii., part 3.)

It was illustrated by drawings of the Dumbuck Crannog by Mr. W. A. Donnelly, photographs of which were thrown on the screen by the oxyhydrogen lantern.

A discussion which followed was taken part in by Mr. Goodchild, F.G.S.; Mr. John Smith, Mr. W. A. Donnelly, and the Author.

Mr. GOODCHILD, F.G.S., of H.M. Geological Survey, gave a resumé of an extensive paper on "The Natural History of the Scottish Zeolites and

Digitized by Google

their Allies," chiefly in reference to the specimens under his charge in the Edinburgh Museum of Science and Art [now the Royal Scottish Museum].

[Printed in full, and issued as a supplement to the present volume of the *Transactions* (see vol. xii., supplement, 1904).]

The characters of the minerals were illustrated by a large series of original drawings, and the localities where they occur, by photographs, which were thrown on the screen by the oxyhydrogen lantern.

The LARGE HALL, SOCIETY'S ROOMS, 207 BATH STREET, 12TH MARCH, 1903.

Mr. JAMES STARK, *Vice-President*, in the Chair.

On the motion of Mr. JAMES NEILSON, Port-Dundas, a sum not exceeding £15 of the Society's funds was voted for Library purposes during the current session.

Councillor Archibald Campbell, Springfield Quay, was elected an Ordinary Member of the Society.

Mr. Thomas Ferguson, 161 Main Street, Barrhead, was elected an Associate Member.

Mr. JAMES NEILSON, Milnbank, read a paper entitled "Notes on the Geology and Archæology of Syria and Palestine." [For a Summary see page 239.]

It was illustrated by a series of photographs by the author, mostly taken in Palestine, which were thrown on the screen by the oxyhydrogen lantern.

SPECIAL MEETING.

LARGE HALL, SOCIETY'S ROOMS, 207 BATH STREET, 26TH MARCH, 1903.

Dr. R. H. TRAQUAIR, LL.D., F.R.S., *President*, in the Chair.

The President delivered an Address to a large gathering of the members of the Society and those of other scientific bodies, his subject being "Hugh Miller, and his Palæichthyological Work."

As a palæontologist the name of Hugh Miller was chiefly associated with the fishes of the Old Red Sandstone, of which he was one of the earliest collectors and students. His scientific work in this department was principally to be found in his well-known books, "The Old Red Sandstone," and "Footprints of the Creator." Though not possessing the advantage of an education in comparative anatomy, he had in a high degree the faculty of being able to decipher the crushed and often fragmentary remains of the long-extinct fishes which he found in the rocks, and in some instances his insight into their structure was more accurate than that of Agassiz himself. For example, in the case of *Pterichthys*, the ventral surface of which was figured by Agassiz as the

Digitized by Google

back, Hugh Miller had previously drawn both the under and upper sides quite correctly. On the other hand, Miller made a big mistake in mixing up two different creatures—*Homosteus* and *Glyptolepis*—in his so-called "*Asterolepis* of Stromness," neither of the two belonging to that genus as instituted by d'Eichwald. In this, however, it must in fairness be stated that Miller was misled by Agassiz. So far as his fossil fish work went, and unfortunately this was comparatively small in amount, Hugh Miller was a worthy pioneer in that new direction of the subject further developed by Pander and Huxley, and now adopted by all palæichthyologists, namely, the bestowing of careful attention to structural details, instead of being satisfied merely with noting external form, and the configuration of teeth or scales. He was a fierce opponent of the doctrine of evolution, or "progressive development," as it was called in those days, of which the main idea was then in a very crude state, and Darwin's epoch-making work—"The Origin of Species"—did not appear till two years after Miller's death. But he was so devoted to scientific truth that many were of opinion, if he had lived on into post-Darwinian days, he too, like the overwhelming majority of modern naturalists, would have recognised the reasonableness of the doctrine of descent.

The Address was illustrated by a large series of photographs and drawings which were thrown on the screen by the oxyhydrogen lantern.

SOCIETY'S ROOMS, 207 BATH STREET, 9TH APRIL, 1903.

Mr. JAMES STARK, *Vice-President*, in the Chair.

Mr. James L. Begg, and Mr. Thomas Begg, junr., Elms, Mount Vernon, were elected Associate Members of the Society.

It was proposed and unanimously agreed that the congratulations of the meeting should be sent to the Society's old friend and Honorary Member, Mr. Thomas Scott, on his receiving the honorary degree of LL.D. from the University of St. Andrews. Similar congratulations were agreed to be sent on behalf of the Society to Mr. B. N. Peach, of H.M. Geological Survey, on his reception of an LL.D.-ship from the University of Edinburgh.

Dr. JOHN HORNE, F.R.S., F.G.S., of H.M. Geological Survey, read a paper on "The Geology of the Loch Maree District."

At the outset Dr. Horne indicated that the area which surrounds Loch Maree forms part of the belt extending from Eribol to Sleat in Skye, which had been affected by powerful Earth-movements in post-Cambrian time. He gave an account of the sub-divisions which had been established by the Geological Survey in the Archæan rocks, the Torridon Sandstone, and the Cambrian strata. He referred to the very valuable suite of Trilobites which were found in the fucoid beds in the district—fossils which had beyond any doubt proved the Cambrian age of these beds. Thereafter he described the complicated system of folding and

Digitized by Google

reversed faults or displacements, by means of which great inversions of the strata had been produced, and slices of the old Archæan floor had been driven westwards and made to overlie the rocks of the younger formations.

The paper was fully illustrated by a large series of photographs thrown on the screen by the oxyhydrogen lantern.

SOCIETY'S ROOMS, 207 BATH STREET, 7TH MAY, 1903.

Mr. JAMES STEEL, *Vice-President*, in the Chair.

Mr. Angus Warden, 17 Abbotsford Place, was elected an Associate Member of the Society.

Mr. JAMES STARK, *Vice-President*, exhibited specimens of Laterite, and Silicified Wood from Burma. He pointed out that though these differed widely from each other in composition, and occurred under very different conditions, they probably derived their origin from the same source, the laterite directly, and the silicified wood indirectly, from the decomposition of certain dioritic and schistose rocks, which are largely composed of aluminous silicates. A detailed account was then given of the manner in which the formation of these products had been brought about.

Mr. PETER MACNAIR, Joint Hon. Secretary, exhibited a number of specimens of the somewhat rare mineral, Struvite, recently presented to the Kelvingrove Museum. These had been found in the digging for the foundation of a new church at Hamburg, where it had been formed, apparently, through the decomposition of animal matter. It was deposited as a precipitate from neutral or alkaline solutions, containing phosphoric acid, ammonia, and magnesia. The crystalline habit and optical characters of the mineral were also described.

Notes of recent Excursions were read as follows (see Excursions for the Season of 1903 in next part of *Transactions*, vol. xii., part 3):—

On Saturday, 17th January, 14th February, and 14th March, to the Geological Galleries, Kelvingrove Museum. By Mr. PETER MACNAIR, Conductor.

On 28th March, to Arkleston Railway Cutting, Paisley. By Mr. MATTHEW BLAIR, Conductor.

On the Spring Holiday, 11th April, to Devon Valley. By Dr. B. N. PEACH, F.R.S., of H.M. Geological Survey, Conductor.

On 25th April, to Corrieburn. By Mr. JAMES ANDERSON, Conductor.

SOCIETY'S ROOMS, 207 BATH STREET, 28TH MAY, 1903.

Mr. JAMES STARK, *Vice-President*, in the Chair.

Mr. William Ferguson, LL.D., of Kinmundy, Mintlaw, Aberdeenshire, and Mr. Alexander Hill, 302B St. Vincent Street, were elected Ordinary Members of the Society.

Digitized by Google

Notes on recent Excursions were read as follows (see Excursions for the Season of 1903 in next part of *Transactions*, vol. xii., part 3):—

On 11th April, to Ardrossan Waterworks Extension, by Mr. JOHN SMITH.

On 9th May, to Glorat, Campsie, Stirlingshire, by Mr. JAMES ANDERSON.

On 21st May, to St. Andrews, Fifeshire, by Mr. GOODCHILD, F.G.S., of H.M. Geological Survey.

Mr. PETER MACNAIR, Joint-Hon. Secretary, read a paper entitled "A Day on Ben More, Assynt," in which he gave a graphic sketch of the tract of wild mountainous country lying between the Isle of Skye and the Kyle of Durness, a district which has of late attracted the attention, not only of the British geologist, but of students of the earth's history all over the world. Along this line of country, and more particularly that part of it stretching from Ullapool to Loch Broom, there is a series of mountains—Coul More, Ben Stack, Sulven, Canisp, Fionaven, and others, which in their peculiar structure and conformation bear evidence of a vast series of changes which passed over the earth at an early period of its history. The story of the discovery and unravelment of the complicated structures which characterise the mountains along this tract of the north-west of Scotland is one of the fascinating and romantic chapters in Scottish geology, and is identified with the names of its pioneers—MacCulloch, Nicol, Murchison, Geikie, and others. Selecting Ben More as a typical portion of the region, Mr. MACNAIR detailed the various earth-movements and displacements of rock-masses met with during its ascent. He also spoke of its extremely interesting flora, and the relations of some of the existing forms to those of fossil type, and concluded his paper by expressing a hope that his description of those wonderful phenomena of our country might induce some of the members of the Society to take a deeper interest in the rock-history of the Scottish Highlands.

The paper was illustrated by a number of fine photographs of the geological features of Assynt, thrown on the screen by the oxyhydrogen lantern.

The CHAIRMAN (Mr. Stark) then declared the forty-fifth Session of the Society closed, with a hope that the members would have a good geological holiday time, and bring back with them material for a new campaign in October next.

Digitized by Google

EXCURSIONS FOR THE SEASON OF 1901.

To Sections on the new Lanarkshire and Ayrshire Railway, Renfrewshire, on Saturday, 10th November, 1900—Messrs. J. B. Murdoch and Peter Macnair, conductors. Proceeding to Giffnock Station by 1-12 p.m. train on the Busby Railway, the party walked up the Kilmarnock Road to Whitecraigs, a station on the new railway, where they inspected the deep sandstone and Boulder-clay cuttings. Lying upon a post of the Giffnock "Moor rock," it was extremely interesting to find here an exposure of the Orchard Limestone, very much in the position which Captain Stewart assigned to it in his paper on the "Limestones in the Parishes of Cathcart and Eastwood," contributed to the Society in 1883.* This bed, which dipped N. by E., ran out towards the S.-W. against the deposit of Till which seems at this place to have replaced the denuded upper strata. Not long after the date of this excursion a large part of the excavations, out of which a great deal of sandstone suitable for building had been taken, were filled in and dressed down, so that this notable Orchard limestone exposure is now altogether hidden. The outcrops of the other limestones in this locality, the Holeburn and the Arden cementstones, were afterwards inspected by the members, who returned to town *via* Thornliebank, after a walk of about four miles.

To Giffnock Quarries, and Cuttings on the Lanarkshire and Ayrshire Railway, Renfrewshire, on Saturday, 23rd March, 1901—Mr. J. B. Murdoch, conductor. The object of this Excursion, *via* Giffnock Station on the Busby Railway, by 2-12 p.m. train from the Central Station, was to inspect the thick-bedded sandstones presently worked at Braidbar and the occasional old land-surfaces with abundant plant-remains which they contain, and of which some good examples were got. From this the party proceeded to Birkenshaw Tileworks, to the south, where a cutting was being made through a large mound of Boulder-clay over which the Busby Railway passes. The clay taken from this cutting had been found to contain a large number of Carboniferous fossils in a most beautiful state of preservation. They had evidently been derived from some of the higher-lying shale-beds which the ice depositing the Boulder-clay had broken up in its passage from the N.-W., and being carried along with it, had really become small boulders in the clay. Many fine examples were got by the members. A bed of peat lying under part of the brick-clay at Birkenshaw was afterwards inspected. The return home was made *via* Cathcart, along the line of the new railway, the total walk being about four miles.

To Colintraive, Argyllshire, on Saturday, 8th April—Mr. David Nimmo, conductor. The day turned out utterly stormy and one of the worst of the season, so spoiling this interesting Excursion, only one or two

* "Notes on the Limestones in the Parishes of Cathcart and Eastwood, Renfrewshire. By James Stewart of Williamwood. With a Map and Section." *Trans.* vol. vii., part 1, 1883, page 158.

Digitized by Google

members turning out to support the leader. It had been intended to inspect the exposures of contorted mica-schists and schistose greywackes on the shores of Loch Ridden, and their interesting folded strain-slips, but these had to be held over for another occasion. A full description of the rocks of this district will be found in Mr. C. T. Clough's "Geology of Cowal," one of the Geological Survey Memoirs, issued in 1897.

To Arthur's Seat, Edinburgh, on Saturday, 20th April—Mr. J. G. Goodchild, conductor—a joint excursion with the Edinburgh Geological Society. On the arrival of the Glasgow members the party met at the Waverley Station about 2-15 p.m., and first visited the quarry along the Radical Road at the north end of Salisbury Crags, where the great sheet of dolerite forming the precipices was seen to be intrusive in the Cornstones or Craigmillar Sandstone. Then, crossing the west slopes of Hunter's Bog across the outcrop of the Ballagan Clays, they examined the first formed of the lava-streams on Arthur's Seat—the bed which forms the western slope between Haggis Knowe and St. Anthony's Chapel. Going towards Dunsappie they examined a remarkable bed of geyserite, and then went on to Samson's Grave, a fine example of a small rock-basin, on the sides of which glacial markings are well displayed. They then crossed the outcrops of the various eruptive rocks of Whinney Hill and Crow Hill, at the south end of which there is evidence of a later set of volcanic eruptions, forming the main mass of the higher parts of the hill. These may represent the effects of a minor parasitic cone which broke through the flanks of the Edinburgh volcano at a period when that hill was nearing its maturity. The red staining of the products of this later eruption, due perhaps to infiltration of turgite from the Triassic rocks which covered the hill in later times, was noted. A visit was then paid to the summit, and thence to the outcrop of the celebrated basalt of the Lion's Haunch. After that the party followed the Queen's Drive round the south side of the hill, noting the intrusion of the basalt sheet which forms Samson's Ribs into the coarse agglomerate of the neck. A study of the well-known *roches moutonnée* along the Queen's Drive brought the excursion to an end. The total walk was about four miles.

To Rankinston and Dalmellington, Ayrshire, on Saturday, 23rd May (Victoria Day)—Mr. John Smith, conductor. Leaving St. Enoch Station, G. & S.-W. Ry., at 7-20 a.m., the members on reaching Patna changed into the train for Rankinston, and thence proceeded up the Water of Coyle to Rankinston Glen, where a fine seam of anthracitic coal was seen embedded in the exposed strata, though these were not apparently in any way affected. Further up the glen is exposed a great sill of dolerite, the heat from which may have been the transposing cause. This anthracite has been largely mined in the district as a blind coal. Taking the moorlands for some miles the party next examined the shale and ironstone mounds—remains of the old pit-workings—lying at intervals on the surface, and obtaining a number of good specimens of Carboniferous fossils. At one heap much volcanic ash with black veins was observed, affording clear

Digitized by Google

evidence that part of the ash had been altered to serpentine. Remnants of the outcrops of several other dolerite sills were seen prominent in the moorlands, and from the top of Ben Beoch Craig, 1521 feet, a wonderful view of the great wilderness of blocks which, in the course of time had fallen away from this remarkable inland cliff, was obtained. Many granite blocks, transported from the hills south of Loch Doon, were also noted. On reaching Dalmellington the members had tea, and left for Ayr and Glasgow at 6 p.m. The total walk extended to about seven miles.

To Portincross, West Kilbride, Ayrshire, on Saturday, 4th May—Mr. James Stark, conductor. Leaving St. Enoch Station (G. & S.W. Ry.) at 2 p.m., on reaching West Kilbride Station the members traced a large dolerite dyke about 60 feet thick, exposed in a cutting, till they reached Portincross, two miles distant, where it was lost to sight under the sea. Just previous to that it traversed a sharp anticline in the Upper Old Red Sandstone. At this place for about half-a-mile the strata were seen to be turned right on edge, and to be enveloping a patch of the cementstone series, which had been greatly contorted, crushed, and faulted down, amongst the red sandstones. A band of conglomerate about 100 feet thick, and packed with large round pebbles of pink quartzite—probably a re-formation of the Lower Old Red basal conglomerate—was very prominent at this place. Portions of the 25-feet, 50-feet, and 100-feet Raised-beaches were examined, also the imposing 300-feet escarpment of Goldenbury Hill, composed of Red Sandstone, capped by an intrusive sheet of pink Felsite, which must have been cut back by the sea since glacial times. The party afterwards returned to Glasgow by train. The total extent of the walk was about six miles.

To Nethan Glen, Lanarkshire, on Saturday, 1st June—Mr. David Nimmo, conductor. Leaving Central Station, Caledonian Railway, at 1 p.m., the members went to Tillietudlem, whence they walked along the railway line till they crossed the Nethan by the viaduct. Here they inspected a fine exposure of sandstone, lying just under the Gair limestone, which is seen on top of the quarry. Further along the railway cutting fine sections of the series of rocks, from the Gair to the Belston limestone, were found to be richly fossiliferous. When the bed of the Nethan was reached the fine example of river erosion it affords was admired, and higher up the stream the junction of the Lower Limestones with the Calciferous Sandstone series, the latter being faulted down against a boss of pale pink felsite, were noted. By the time that Auchenheath Station was reached it was nearly 7-30 p.m.—train-time—and the party left for Glasgow. The distance walked was about five miles.

To Great Cumbrae, Bute, on Saturday, 15th June—Mr. Joseph Sommerville, conductor. Leaving St. Enoch Station, G. & S.W. Ry., at 1-20 p.m. for Fairlie, on arrival there the steamer soon transferred the party to Keppel Pier, Cumbrae. From a short way east of "The Lion Rock" the members walked along the Lower Raised-beach, examining the Upper Old Red Sandstone dipping westward to Kames Bay, where it strikes the line

Digitized by Google

of fault, running nearly due north and south, which has thrown up the Upper Old Red against the Lower Carboniferous strata exposed on the west side of the Bay. The pinkish-coloured trachyte dykes were next examined, and attention was paid to the great weathering-out of the large crystals of orthoclase, also that these dykes had been cut through by the younger basic ones, such as these forming "The Lion Rock" and "The Deil's Dyke." The latter, greatly weathered-out from the surrounding strata, forms a great wall at the western side of the Marine Observatory, and when traced seaward can be seen to divide into two, where fragments of a clastic rock are found embedded, evidently carried along in the molten magma. The day afterwards proving wet, the party went to the Marine Station, where, under the guidance of Mr. Gray, the curator, they inspected the most recent additions to the museum; and returned to Glasgow *via* Fairlie. The distance walked did not exceed three miles.

To Killin, Perthshire, on Saturday, 22nd June—Mr. Peter Macnair, conductor—a joint excursion with the Natural History Society of Glasgow. Taking train at Buchanan Street Station, Cal. Ry., at 7-15 a.m., the party reached Killin about 10 a.m., and lost no time in starting to climb Creag na Caillich, a mountain of nearly 3000 feet above sea-level. It was pointed out that this might be called the great central axis of folding, along which the plicating forces had exerted themselves from north-east to south-west. On the ascent the limestones, garnetiferous schists, phyllites, greywackes, hornblende schists, felsites, serpentines, and various other rocks were inspected. Fine sections of the Loch Tay Limestone, and its accompanying altered basic rocks, were seen. Ascending from the Loch to the Kenmore Road a number of interesting sections at Drum-na-Larig were noted. The limestones had been extremely folded, the axis of the folds hading towards the north-west, and the overfolding consequently towards the south-east. The undersides of the folds were clearly reduced in thickness, and the whole evidence went to show that the thrust had been from the north-west.

Evening Excursions in 1901.

To Provan Gasworks, Glasgow, on Thursday evening, 25th April—Mr. R. W. Dron, C.E., M.E., conductor. A circular excavation for the gasholder was first examined. The Boulder-clay here exposed was from 15 to 20 feet deep, and the underlying rock-cutting about 30 feet, the junction being well displayed. The sandstone and accompanying shale, belonging to the Millstone Grit series, have evidently been the site of an ancient Carboniferous forest, numerous sections of tree stems (*Sigillaria*), from 12 to 18 inches in diameter, being found in it. The exposure was from 4 to 6 feet in height. They nearly all stood vertical, and were very well preserved, showing in many cases the *Stigmaria* rootlets. An interesting light grey sheet of dolerite, which had caused great alteration in the adjoining sandstones and shales, the former having in some places been

Digitized by Google

altered almost to a quartzite, was also seen in the cutting. The extensive Boulder-clay cuttings for sidings, &c., were afterwards examined—showing one of the finest exposures ever opened out in or near Glasgow. It was being removed in successive "benches," showing a total depth of about 80 feet. Though composed of the usual hard stiff blue clay, it did not contain the general proportion of boulders. Of those seen several were of limestone, beautifully striated, and others of metamorphic rocks, ice-borne from the "Marginal Highlands."

To the Glasgow International Exhibition, on Thursday evenings, 13th June, 27th June, 8th August, and 22nd August—Mr Peter Macnair, conductor. The object of these meetings was to make a full inspection of the metallurgical and mineral collections which had been sent for exhibition by the Canadian, Australian, and other Colonial Governments, and many interesting and valuable exhibits of the kind were noted.

EXCURSIONS FOR THE SEASON OF 1902.

To Darnley, Renfrewshire—Mr. Peter Macnair, conductor—on Saturday, 26th October, 1901. The party left St. Enoch Station at 1-50 p.m. for Kennishead, and walked to the opencast workings in the Arden Cement Limestone, where they were shown over the workings by the kind permission of Mr. Kirkwood, the lessee. At this part of the ground, the shale which lies above the cementstone has turned out to be extremely rich in fossils, and a number of fine specimens of the characteristic species were secured. The members then walked back to the station for town, the total walk having not extended beyond three miles.

To the Pumping Station of the Glasgow Main Drainage Works, Dumbarton Road, on Saturday, 15th February—Mr. David Chalmers, conductor. Under the guidance of an assistant engineer, the party was taken down by ladder into a cutting through the Possil Sandstone, 80 feet long, by 60 feet wide, and 40 feet deep. The section in descending order showed sand 3 feet, Boulder-clay 6 feet, shale 3 feet, flaggy sandstone 6 feet, shale 2 feet 6 inches, coal 1 foot 3 inches, flaggy sandstone 1 foot 6 inches, shale 4 feet 6 inches, ironstone 3 inches, coal 1 foot, fireclay 2 feet 6 inches, coal 1 foot 6 inches. In a paper by the late Dr. John Young, F.G.S., *Transactions*, vol. iii., part 2, page 298, this group of rocks is placed amongst the Possil and Govan Ironstone series, which is nearly 900 feet thick, and as its name shows, containing the valuable deposits of iron ore which have brought so much wealth to the district. Some fine examples of faulting were seen, one having a downthrow of about 15 feet, dipping north.

To the New Dock, Yoker, on 15th March—Mr. Joseph Sommerville, conductor. Mr. Stevenson, resident engineer, guided the party over the excavations. The excavation was almost entirely cut out of Boulder-clay, and only at the western end was shale found, and it was

Digitized by Google

fossiliferous, containing *Discina nitida*, &c. It was full of nodules of pyrites (sulphide of iron). The first 20 feet of clay above the shale was reddish and full of stones, many of which had come from the Kilpatrick Hills, and from the adjoining sandstone rocks. A good many, however, were clearly of West Highland origin. On the top of this clay lay about 25 feet of the dark blue clay, so common in and around Glasgow, in places separated from it by a layer of fine sand, and in others by a pavement of boulders. These two clays had evidently come from different directions, the lower from the N.W., and the upper from the N.E., affording unmistakable evidence of two glaciations. In the red clay Mr. Stevenson found a boulder of sphærosiderite (carbonate of iron) which, there is little doubt, came from the Campsie Hills. The late Dr. John Young, F.G.S., described one from Craigenglen in the *Transactions*, vol. ix., page 425, and a microscopic section of it made by him was exhibited by the conductor.

To Glenfarg, Perthshire, on Monday, 31st March—Mr. B. N. Peach, F.R.S., H.M. Geological Survey, conductor—a joint excursion with the Edinburgh Geological Society. The Glasgow party left Queen Street Station at 8-15 a.m., meeting their Edinburgh friends at Glenfarg. From thence they walked through Glenfarg, the first four miles through the Lower Old Red andesitic lavas, agglomerates, and intrusive rocks. On leaving the glen the Upper Old Red Sandstone was inspected; and at Dron farm the Ballagan beds, the furthest northern extension of Carboniferous rocks in the East of Scotland, were examined. There were also seen some extensive Boulder-clay beds, and the Raised-beaches of the Carse of Gowrie. After reaching Bridge of Earn the party had tea, and at 6-48 p.m. the Glasgow members left by train for home, the walk having extended to about eight miles.

To Cuttings on the new branch of the G. & S.-W. Ry., from Johnstone to Dalry, Renfrewshire, on Saturday, 12th April—Mr. John Smith, conductor. Taking train from St. Enoch Station to Howwood at 1-20 p.m., the party walked through some of the cuttings on the new branch of the G. & S.-W. Ry., a considerable portion of the rock exposed in Castle Semple grounds being volcanic, and underlying the Carboniferous limestone series. Before Lochwinnoch was reached thick Boulder-clay was seen resting on a bed of gravel, the former containing a few West Highland rocks. Beyond Lochwinnoch a cutting in sandstone and shale, with several Tertiary dykes, was met with, one of considerable size. Near the Maich Glen a remnant of the Index limestone had been laid bare. The total walk to Beith Station, where the members took train for home, was about seven miles.

To Murroch Glen and Auchenreoch Glen, Dumbartonshire, on Saturday, 26th April—Mr. William Armour, C.E., conductor. Leaving town from Central Station at 1-50 p.m., the members walked from Dumbarton up the valley of the Leven till they struck the mouth of Murroch Glen, and, turning to the right, ascended till they reached Auchenreoch Glen, which enters it some way up. In places the rocky banks showed

Digitized by Google

fine examples of river erosion — sometimes extending into lofty cliffs cut sheer through the Ballagan Beds, and belonging to the Calciferous Sandstones of the Carboniferous Series. Good specimens of fibrous gypsum and celestite were obtained here by some of the members from the underlying rocks. A great variety of boulders in the channels of the burns was noticed—granite, contorted schist, greywacke, and sandstone, probably all derived from the Boulder-clay, which caps the rocks in places to a great depth. The party came back across the moor, and, striking the hill road, got to Dumbarton in time for their train to Glasgow. The distance walked was about six miles.

To Cleghorn and Cartland Crags, Lanarkshire, on Saturday, 10th May—Mr. James Stark, V.P., conductor. Leaving the Central Station at 1-30 p.m., the party went on to Cleghorn, where a special stop was made, and from thence they proceeded along the Mouse Water for about three and a half miles, the stream descending some 300 feet through highly picturesque gorges, varied by opener portions. It here runs across the track of the ice-sheet, which, during the glacial period, filled the Central Valley of Scotland, and the pre-glacial channel of the stream has been choked up with Boulder-clay. On the melting of the ice-sheet, the river was in many places unable to find its old bed, and therefore, taking the lowest levels, cut its way down to the rock, through which it has since worn the series of gorges, which frosts and rains have not as yet succeeded in widening out into an open valley. Those below Cleghorn Bridge, west of Jerviswood House, and that of Cartland Crags, are notable examples of post-glacial erosion, while the open parts south of Cleghorn House, at Leechford, and at the foot of the "Stey Brae," are places where the post-glacial channel crosses the pre-glacial one. Glenburnie and the hollow at Baronald are portions partially washed out of the latter, and re-exposed during the time that the Mouse has been wearing out the present channel. The rock here—mainly Lower Old Red Sandstone, bent into a long syncline from Kilncadzow almost to Tinto, the dip S.E. at the former and N.E. at the latter—can hardly be less than 10,000 feet thick, and composed throughout of felspathic sandstones and iron-stained mudstones. Overlying them on the right bank from Cleghorn gorge to near Lockhart Mill are red shales capped by thick yellow and greenish sandstone. An outlier of these is cut off by the Mouse, a fine section on the left bank shortly above Leechford lying unconformably on the O.R.S. These belong to the Calciferous series, equivalents of the Ballagan beds of the Campsie Hills, and the basement of the Coal-measures of Central Scotland. As they rest here on the Lower Old Red, the absence of the andesites and Upper Old Red sandstones and cornstones shows that this part of Scotland had then "its head above water," and was subjected to denudation for a very long period, during which it furnished much material for the formation of the Coal-measures then being quietly deposited in the area to the north.

To Dunbar, East Lothian, on Thursday, 22nd May (Victoria Day)—Mr. J. G. Goodchild, F.G.S., H.M. Geological Survey, conductor—a joint

Digitized by Google

excursion with the Edinburgh Geological Society. By train from Queen Street Station at 7-45 a.m., the Glasgow members proceeded to Dunbar, where, after visiting the Harbour and Castle, and examining the lavas and intrusive rocks exposed there, they walked through the older town chiefly occupied by the fishing folk, and then eastwards along the shore over the "Red Rocks," so well exposed below the Promenade. Attention was directed to the very close resemblance of these rocks to the Bunter sandstone at Whiting Bay and elsewhere in Arran, and to the possibility of their being really of Triassic, instead of Upper Old Red age, as the Survey has represented them. A great fault was then crossed to some of the upper members of the Yoredale Rocks, probably on the horizon of the beds close above the Edge Coal series of the Lothians, the sandstones containing abundant traces of *Spirophyton cauda-galli*, and stems of encrinites. Then they proceeded to the Yoredale limestones at Catcraig, highly dolomitic through infiltration of magnesian carbonates, from the New Red rocks that lay over this area in recent geological times. There are many fossils in the associated shales. It was stated by the conductor that Mr. William Gunn, F.G.S., of the Survey, had recently made the important identification of these limestones with the Eelwell and other limestones near Berwick, so that a satisfactory correlation of the Dunbar Hurlet limestone with its equivalent in the North of England has now been made. Some fine glacial markings were seen, and the overlying Boulder-clay contained many far-transported blocks. The remarkable red breccia below the Promenade was afterwards examined. It contains liver-coloured quartzites, like those usually occurring in the Bunter, and also fragments of Lower Carboniferous limestones with characteristic fossils. Possibly these rocks might represent the basal breccia of the Bunter sandstone. After tea at Dunbar, the party returned to Glasgow, the whole distance walked being about eight miles.

To Kinghorn, Fifeshire, on Saturday, 31st May—Dr. Marian Newbigin, conductor—a joint excursion with the Scottish Natural History Society and the Natural History Society of Glasgow. The Glasgow party left Queen Street Station at 1-20 p.m. After reaching Kinghorn they met their Edinburgh friends and walked to Burntisland. On the way excellent exposures of volcanic rocks were seen in King Alexander's Crag, and also some interesting examples of ejected blocks, including some figured by Sir Archibald Geikie in the *Geological Magazine*, 1864, and in his "Text-book of Geology," 1885, fig. 294.

To Dumgoyne, Campsie Fells, Stirlingshire, on Saturday, 7th June—Mr. James Steel, conductor—a joint excursion with the Natural History Society of Glasgow. Taking train at Queen Street Station at 1-37 p.m., the joint-party proceeded to Dumgoyne Station; starting at once for an ascent of the hill, 1401 feet high—an old volcanic neck, of which there are many in the neighbourhood. Dumgoyne, however, stands out very prominently from all the others, the surrounding rocks—the Upper Old Red and Carboniferous strata—having been largely denuded away from it. After a pleasant walk of about four miles, the members took train for Glasgow.

Digitized by Google

To Aberfoyle, Perthshire—Mr. Peter Macnair, Assist. Hon. Secretary, conductor—on Saturday, 21st June. Taking train at Queen Street Station at 1·37 p.m. for Aberfoyle, the members left the railway and proceeded to Pow Burn to examine the supposed Ordovician series, which appears to be wedged in between the Lower Old Red sandstone on the east, and the Highland crystalline schists on the west, and consists of black shales, cherts, and grits, some good sections being visible in the Burn of Arndrum. Some of the Officers of the Survey think these rocks are identical with a similar group containing fossils of Arenig age which occur in the South of Scotland. The identification with those of the southern uplands is, however, entirely dependent upon the similarity of their petrological characters, no fossils having yet been detected in them. In Forfarshire, Mr. Barrow of the Survey believes that those supposed Ordovician rocks are separated from the Highland ones by a line of thrust, but no evidence of this is found in the Aberfoyle rocks. The basement conglomerate of the Lower Old Red Sandstone was also closely examined, and the quarry where a barytes vein was formerly mined was visited. The party then returned to Aberfoyle, and had tea before leaving for Glasgow at 7·25. The walk extended to about six miles.

To Saltcoats, Ayrshire—Mr. David Chalmers, conductor—on Saturday, 16th August. Leaving St. Enoch Station at 2 p.m., the party travelled to South Beach Station, Ardrossan, from whence they visited the Mussel bed and Limestone reefs which come to the surface on the shore close by. These strata, known as the "Linn limestones," are largely worked about this district, and are very fossiliferous. Proceeding from this to the Old Saltpans in Saltcoats (whence it doubtless takes its name), a number of volcanic rock-exposures were seen, also dykes running at various angles through them. A coal seam near here showed some interbedding by lava-flows, which had rendered the coal columnar in places. Going next to the Old Harbour, the members examined several more massive lava-flows in contact with shale, which they had evidently much altered by heat. A very fine example of *Sigillaria*—one of the Carboniferous trees, not less than 2 feet 3 inches in diameter—was seen in this shale, and on some of it being cut away the bark-markings were found to be specially distinct. The party afterwards took the train at Saltcoats Station, having had an easy walk of not over two miles.

Evening Excursions in 1902.

To Arkleston, Paisley, Renfrewshire—Mr. Matthew Blair, conductor—on Thursday, 15th May. Leaving St. Enoch Station at 6 p.m., the party proceeded to Gilmour Street Station, Paisley, where they were met by an official of the Railway Company, who conducted them back along the line to Arkleston Bridge and Cutting. Here they inspected the interesting exposure of intrusive dolerite which, since the opening out of the tunnel through it, shows in a beautiful way the effect the volcanic rock has had on

Digitized by Google

the shale and limestone beds lying in contact with it, and between which it has forced its way. There is also a seam of coal which has evidently been rendered columnar by the heat. The members then went back to Paisley. The distance walked was under three miles.

To Giffnock, Renfrewshire — Mr. Peter Macnair, conductor — on Thursday, 12th June. Leaving by train from Central Station for Thornliebank at 6-15 p.m., the party went direct through the old quarry workings to the well-known annelid beds and flagstones. Their gradual thinning out towards the east was noticed, and a somewhat animated discussion as to its cause was entered on. Afterwards the party went on to Braidbar quarry, where a number of good specimens of plant-remains from the shale above the "Moor Rock" were obtained, and they then went home *via* Giffnock, after a pleasant walk of under three miles.

To Cathkin, Lanarkshire — Mr. David Chalmers, conductor — on Thursday, 19th June. Leaving the Central Station at 6 p.m., the members reached Rutherglen and proceeded up the East Kilbride hill road, due south, till they reached, not far beyond Burnside, the old quarry where the basalt shows distinct though roughly-moulded columnar structure, very much jointed. Further up they examined another quarry where the columns are bent, as described in Ure's well-known "Rutherglen and East Kilbride," published in 1791. Still higher up the hill they reached the extensive workings from which road-metal is still extensively quarried, and found that the rock here also contained many jointed columns. At this exposure it is an olivine basalt, and yields very good sections for the microscope. The party then had a look at Cathkin Park, where the surface is terraced by successive lava-flows, affording good examples of trap-stepping. Retracing their way to Rutherglen Station, they took train to Glasgow, after a pleasant walk of about four miles.

Digitized by Google

ABSTRACT of TREASURER'S ACCOUNTS for Year ending 30th September, 1901.

CASH ACCOUNT.

RECEIPTS.

To Cash in Bank on Deposit,	£135 0 0	
,, ,, in Treasurer's hands,	4 18 11	
		£139 18 11
,, Subscriptions for current year and Arrears,		68 0 0
,, New Members,		10 0 0
,, Life Members' Subscriptions,		15 15 0
,, Associate Members' Subscriptions,		2 5 0
,, Publications and Catalogues sold,		5 5 3
,, Interest on Funds,		7 12 9
		£248 16 11

EXPENDITURE.

By Printing Volume XI. of Transactions,	£45 5 0		
,, Engraving Illustrations for Transactions,	8 1 6		
		£53 6 6	
,, New Books,	...	7 19 10	
,, Subscription to Millport Marine Station	£1 1 0		
,, Subscription to Palæontographical Society,	1 1 0		
		2 2 0	
,, Rent, Insurance, and Attendance,	£13 10 0		
,, Printing and Postage of Circulars, &c.,	20 11 9		
,, Lantern and Lecture Expenses,	3 18 3		
,, Collector's Commission,	2 0 6		
,, Disbursements by Hon. Secretaries,	5 3 9		
,, Disbursements by Librarian,	1 7 0		
,, Postages, Stationery, and Petty Expenses,	1 10 1		
		48 1 4	
,, Cash in Bank on Deposit,	£132 0 0		
,, Cash in Treasurer's hands,	5 7 3		
		137 7 3	
		£248 16 11	

STOCK ACCOUNT.

To Balance to Credit,		£807 7 3
		£807 7 3

By Campbeltown Corporation Loan,	£170 0 0	
,, Cash in Bank and on hand,	137 7 3	
		£307 7 3
,, Property—		
Books,	£440 0 0	
Furniture, Bookcases, and Microscope,	60 0 0	
		500 0 0
		£807 7 3

LIFE SUBSCRIPTION ACCOUNT.

To Balance to Credit,		£241 10 0
		£241 10 0

By Balance at 1st October, 1900,	£225 15 0
,, New Subscriptions,	15 15 0
	£241 10 0

GLASGOW, 17*th October*, 1901.—Examined and found correct, the balance in Treasurer's hands being Five Pounds, Seven Shillings and Threepence.

D. PEARSON,
JOHN R. M'FARLANE, } *Auditors.*

Digitized by Google

ABSTRACT of TREASURER'S ACCOUNTS for Year ended 30th September, 1902.

CASH ACCOUNT.

RECEIPTS.

To Cash in Bank on Deposit,	£132	0	0						
,, Cash in Treasurer's hands,	5	7	3						
				£137	7	3			
,, Subscriptions for current year and Arrears,				69	2	6			
,, New Members,				10	10	0			
,, Associate Members' Subscriptions,				1	15	0			
,, Publications and Catalogues sold,				0	7	10			
,, Interest on Funds,				7	17	2			
				£226	19	9			

EXPENDITURE.

By Printing Volume XII., Part 1, of Transactions,	£48	0	0						
,, Engraving Illustrations for Transactions,	7	7	11						
				£55	7	11			
,, New Books and Magazines,				6	0	11			
,, Subscription to Millport Marine Station,	£1	1	0						
,, Subscription to Palæontographical Society (2 years),	2	2	0						
				3	3	0			
,, Rent, Insurance, and Attendance,	£15	7	6						
,, Printing and Postage of Circulars, &c.,	14	10	11						
,, Advertising,	2	14	6						
,, Lantern and Lecture Expenses,	2	8	0						
,, Collector's Commission,	2	6	6						
,, Disbursements by Hon. Secretaries,	2	5	7						
,, Disbursements by Librarian,	0	17	10						
,, Postages, Stationery, and Petty Expenses,	1	15	3						
				42	6	1			
,, Cash in Bank on Deposit,	£115	0	0						
,, Cash in Treasurer's hands,	5	1	10						
				120	1	10			
				£226	19	9			

STOCK ACCOUNT.

To Life Subscription Account,				£241	10	0			
,, Capital Account,*				548	11	10			
				£790	1	10			

* NOTE.—Subject to cost of Publishing *Transactions* for Session.

By Campbeltown Corporation Loan,	£170	0	0						
,, Cash in Bank and on hand,	120	1	10						
				£290	1	10			
,, Property—									
Books in the Library,	£440	0	0						
Furniture, Bookcases, and Microscope,	60	0	0						
				500	0	0			
				£790	1	10			

GLASGOW, *3rd November*, 1902.—Examined and found correct, the balance in Treasurer's hands being Five Pounds, One Shilling and Tenpence.

D. PEARSON,
JAS. ANDERSON, } *Auditors.*

Digitized by Google

Digitized by Google

92

Digitized by Google

Digitized by Google

PUBLICATIONS OF THE SOCIETY.

TRANSACTIONS.—Demy 8vo.

Vol. I. Part 1.—The Geology of the Campsie District. By John Young, LL.D., F.G.S. (3rd edition, revised), 2/
——— Part 2.—The Phenomena of the Glacial Drift of Scotland. By Sir Archibald Geikie, F.R.S. (*Reprint*), - 5/
Vol. II. Part 1.—Papers on Local and Theoretical Geology, - - 4/6
——— Part 2.— Do. do. do. (*Out of Print*).
——— Part 3.— Do. do. do. - - - 4/6
Vol. III. Part 1.— Do. [contains "On Geological Time." By Lord Kelvin, F.R.S.], - - - 4/
——— Part 2.— Do. [contains "On Geological Dynamics." By Lord Kelvin, F.R.S.], - - 4/
——— (Supplement)—On the Carboniferous Fossils of the West of Scotland. By John Young, LL.D., F.G.S., and James Armstrong, - - (*Out of Print*).
Vol. IV. Part 1.—Papers on Local and Theoretical Geology, - - 3/
——— Part 2.— Do. do. do. - - 3/
——— Part 3.— Do. do. do. - - 3/
Vol. V. Part 1.— Do. do. do. - - 4/
——— Part 2.— Do. [contains "Geological Climate." By Lord Kelvin, F.R.S.], - - - 4/
Vol. VI. Part 1.— Do. [contains "The Internal Condition of the Earth." By Lord Kelvin, F.R.S.], 4/
——— Part 2.—Papers on Local and Theoretical Geology, - 4/
Vol. VII. Part 1.— Do. do. do. - 5/
——— Part 2.— Do. do. do. - 5/
Vol. VIII. Part 1.— Do. do. do. - 5/
——— Part 2.— Do. [contains "Polar Ice Caps and their Influence in changing Sea Levels." By Lord Kelvin, F.R.S.], - - - - 5/
Vol. IX. Part 1.—Papers on Local and Theoretical Geology, - 6/6
——— Part 2.— Do. do. do. - 6/6

All parts in hand up to this date may be had by members at a very reduced price.

Vol. X. Part 1.—Papers on Local and Theoretical Geology, - 6/6
——— Part 2.— Do. do. do. - 7/
Vol. XI. Part 1.— Do. do. do. - 6/
——— Part 2.— Do. do. do. - 7/
——— (Supplement)—Drift Deposits of Ayrshire. By John Smith, - - - - - - - - 4/
Vol. XII. Part 1.—Papers on Local and Theoretical Geology, - - 5/
——— Part 2.— Do. do. do. - - 5/
——— Part 3.—In Preparation.

PALÆONTOLOGICAL SERIES.—Demy 4to.

Part 1.—Containing Four Plates with many Figures, - - - 3/6

CATALOGUE OF WESTERN SCOTTISH FOSSILS.

Compiled for the Meeting of the British Association, 1876. Crown 8vo, 2/6
Do. do. do. interleaved, 3/6

GEOLOGY OF THE CLYDE DRAINAGE AREA.

Compiled for the Meeting of the British Association, Glasgow, 1901. Demy 8vo, paper boards, - - - - 1/; interleaved, 1/6

THE GEOLOGY OF THE CAMPSIE DISTRICT.

By John Young, LL.D., F.G.S. Third edition, 1894. Demy 8vo, - 2/

THE PHENOMENA OF THE GLACIAL DRIFT.

By Sir Archibald Geikie, F.R.S. (*Reprint.*) Demy 8vo, - - - 5/

THE DRIFT OR GLACIAL DEPOSITS OF AYRSHIRE.

By John Smith. Demy 8vo, - - - - - - - - - 4/

Copies of the above from the Hon. Libn., Mr. J. S. M'LENNAN, at the Society's Rooms, 207 Bath Street, Glasgow; *or through any Bookseller.*

Digitized by Google

THE NEW YORK PUBLIC LIBRARY
INDEXED
ASTOR, LENOX AND TILDEN FOUNDATIONS
695455

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

VOL. XII.—PART III.

1903-1905.

GLASGOW: PUBLISHED BY THE SOCIETY,
AT ITS ROOMS, 207 BATH STREET.
1906.

Wm. Hodge & Co.,] [*Printers, Glasgow.*

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

Digitized by Google

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. XII.—PART III.

1903-1905.

GLASGOW: PUBLISHED BY THE SOCIETY,
AT ITS ROOMS, 207 BATH STREET.
1906.

Digitized by Google

The Editors beg to state that the Authors are alone responsible for the facts and opinions contained in their respective papers.

PETER MACNAIR.
FREDERICK MORT.

Digitized by Google

CONTENTS—Vol. XII., Part III.

PAPER		PAGE
	Obituary Notice of J. B. Murdoch, Esq., of Capelrig.	
XXXIII.	The Geology of the Clyde "Crannogs." By James Neilson, Milnbank. With two Plates, - - -	273
XXXIV.	The Structure of Igneous Rocks. By Frederick Mort, M.A., B.Sc., F.G.S., Demonstrator in Geology, Glasgow University. (Summary), - - - -	290
XXXV.	The Highland Boundary Fault in Arran. By James Stark. (Summary), - - - - - - -	292
XXXVI.	Notes on a Section seen in a Drain on the Lands of Davieland, near Thornliebank. By James Neilson,	294
XXXVII.	On the Modes of Occurrence and the Origins of Intrusive Rocks, with some Remarks upon the Formation of Eruptive Rocks in General. By J. G. Goodchild, Curator of the Scottish Mineral Collection in the Edinburgh Museum of Science and Art. (Summary),	305
XXXVIII.	On Crystallised Carbonite, a Mineral new to Scottish Carboniferous Rocks. By John Smith, - - -	308
XXXIX.	The Crystallisation of Rocks. By Frederick Mort, M.A., B.Sc., F.G.S., *Joint Hon. Secretary*, - -	311
XL.	Notes on the Discovery of an Outlier of the Loch Tay Limestone on Beinn Bhreac, Loch Tay, Perthshire. By Peter Macnair, - - - - - - - -	318
XLI.	The Parallel Roads of Lochaber with Relation to an Ice Cap. By Colin Livingston, - - - -	326
XLII.	Rare Renfrewshire Minerals. By Robert S. Houston, -	354

Digitized by Google

CONTENTS.

PAPER		PAGE
XLIII.	The Geology of the Rouken Glen and its Neighbourhood. With two Plates and Three Diagrams. By Peter Macnair, *Joint Hon. Secretary*, Curator of the Natural History Collections in the Glasgow Museums, Assistant Lecturer on Geology and Mineralogy in the Glasgow and West of Scotland Technical College,	362
	Proceedings for Session 1903-1904,	398
	,, ,, 1904-1905,	404
	Excursions for Season of 1903,	412
	,, ,, 1904,	412
	Abstract of Treasurer's Accounts for year ending 30th September, 1903,	417
	Abstract of Treasurer's Accounts for year ending 30th September, 1904,	418

Digitized by Google

ILLUSTRATIONS—Vol. XII., Part III.

			PAGE
Plate VII.	Dumbuck Crannog. General Plan,	*to face*	283
,, VIII.	1. The Crannog at ebb tide. 2. Cross-section of the "Dock,"	,,	285
Section of Upper Limestone Series in Rouken Glen District,			370
Plate IX.	1. Arden Limestone, Darnley. 2. Estuarine Shale, with Marine Shale and Limestone, above mouth of Darnley Fireclay Pit,	*to face*	373
,, X.	1. Orchard Limestone and Shale, Waulkmill Glen. 2. Estuarine Shale, above Coal and Fireclay, mouth of Darnley Fireclay Pit,	,,	383
Sections of Estuarine Shale below Arden Limestone,			386
Sketch Map and Section of Rouken Glen,			388

Digitized by Google

Obituary.

J. B. MURDOCH OF CAPELRIG.

DEATH has removed another of the small band of enthusiastic geologists who have done so much to advance the interests of the Glasgow Geological Society. The late Mr. J. B. Murdoch of Capelrig was connected with the Society for upwards of forty years of his life, and served for the long period of thirty-one years as honorary secretary. During that time he was also editor of the Society's *Transactions*, and in the work connected with the publication of these he spared neither time nor labour. For the long number of years just mentioned he practically conducted the business of the Society, and its success in the past must be largely attributed to the undivided attention that he paid to its interests. His name will ever be associated with the small band of labourers who originated the Society, and who afterwards did so much to advance the study of our local geology; and though his work was more directly connected with the business rather than with the scientific side of the Society, yet it was none the less valuable, and those who knew him best will most deeply mourn his loss. A more extended notice of Mr. Murdoch's life and work will be given in the next part of the *Transactions*.

Digitized by Google

TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

No. XXXIII.—The Geology of the Clyde "Crannogs."

By James Neilson, Milnbank. With Two Plates.

[Read 12th February, 1903.]

Introduction.—After some hesitation I have decided to call this paper by the above title, as it owes its origin to the problem of the geological conditions which existed about the time when Crannogs were being built, though many of the questions raised have much wider issues than those affecting the first erection of those interesting structures.

The Dumbuck "Crannog" has been brought very prominently before the public of late by a long series of letters and articles (probably not far short of two hundred) which, during a period of about four years, have appeared in the *Glasgow Herald* and the Glasgow *Evening Times*. Many of these were very bitter and personal, and some even contained what almost amounted to charges of forgery or fraud against persons known or unknown in connection with the Dumbuie and Dumbuck investigations.

Believing that these attributions and accusations arose very much from the fact that the Dumbuck "Crannog" and all its contents were largely unique, therefore to some extent incomprehensible, my intention in writing the present paper has been to try to offer a scientific explanation of some of the difficulties

Digitized by Google

which have been advanced by the different writers on the subject.*

The Langbank "Crannog," which is placed on the south bank of the river, was only discovered some years later than the Dumbuck one. [It has to a considerable extent been investigated by a Committee of the Glasgow Archæological Society, and a Report by Mr. John Bruce, F.S.A.Scot., is given in that Society's *Transactions* † in 1905.] It, so far, has not given rise to any prolonged controversy.

THE GREAT HOLLOW BETWEEN CLYDE AND FORTH.—In pre-glacial, or in very early glacial, times, a long and deep hollow extended right across Scotland from the Clyde to the Forth, with its deepest part following the direction of a line drawn from Bowling to Kilsyth, and from Kilsyth to Grangemouth.‡ The summit-level has been proved to have been near Kilsyth, where the hollow was very narrow, and a few feet under present sea-level. From this the eastern extension sloped away till it reached a depth of over 200 feet, while the western one fell to 300 feet below the present sea-level. In all probability there may have been some still deeper places, but of these as yet we know nothing.

This hollow, although nowhere so deep, extended southwards towards the base of the Renfrewshire hills, including the area on which now stand Houston, Johnstone, Renfrew, Paisley, and the low-lying ground near the Clyde extending for several miles above Glasgow. Near Paisley its depth has been proved to have been over 140 feet. A great portion of the surface of this district is perfectly flat, owing to the hollow having been filled up with aqueous deposits at a comparatively recent date. Un-

* A Report of the conjoint visit of members of the Philosophical Society and the Geological Society of Glasgow to the Dumbuck "Crannog" on the 8th April, by Mr. John F. Campbell, will be found in the *Proceedings* of the former body, vol. xxx., 1899, p. 267. It is illustrated by several plates from sketches by Mr. W. A. Donnelly, the discoverer of the structure.

† *Transactions of the Glasgow Archæological Society*, new series, vol. v., part i., 1905, p. 34.

‡ See a paper by the late Mr. James Bennie, "On the Surface Geology of the District round Glasgow, as indicated by the Journals of certain Bores"—*Transactions*, vol. iii., 1871, part i., p. 133. Also one by the late Dr. James Croll, "On Two River Channels buried under Drift"—*Transactions of the Edinburgh Geological Society*, vol. i., 1869, p. 330.

Digitized by Google

fortunately our knowledge of the true topography of the hollow is still very imperfect, especially where the Clyde flows between the trap hills of Bowling and Dumbuck on the north side and those of Renfrewshire on the south. This is mainly because what we do know about it has been almost entirely obtained from the journals of bores, and from pit-sinkings put down in search of coal and ironstone seams, neither of which minerals is known to exist in that locality.

THEORIES ON THE FORMATION OF THE HOLLOW.—The facts stated above leave the way open for three different theories as to the formation of this hollow, and these may be summarised as follows:—

First.—That it has been scooped out by ice in the same way as Loch Lomond and many other Scottish lochs have been formed, though its general shape differs from their long, narrow, glacier-formed basins. Moreover, it deepens where it broadens, and the configuration of the neighbouring hills is not such as to fall in with the requirements of Sir A. C. Ramsay's theory.* On the other hand, if, as some observers contend, we have a continuous bed or dyke of trap extending right across the bed of the Clyde somewhere about Erskine or Dumbuck, which would form a dam, then such a glacial-lake theory seems to me to be the only one possible in the circumstances.

Second.—That the hollow was an old sea-channel. This proposition has much in its favour, especially if it is conceded that, after having been partly filled up, it became a sea-channel again, as I think there is some evidence to show.

Third.—That it was the bed of an old river. The late Dr. Croll said, in his paper quoted above, that the channel was too narrow, and its gradients too steep, to be sea-formed, and that it must have been excavated by a river flowing, at least in its upper part, very much in the line of the present Kelvin, but joining the Clyde near Bowling. Dr. James Geikie read a paper to our Society in support of a similar view, but was stoutly opposed by Dr. John Young, F.G.S., and a very animated discussion arose regarding it, though I cannot find any notice of it in the *Transactions*. Dr. Young held that the Kelvin—a comparatively

* "The Physical Geology and Geography of Great Britain." By [Sir] A. C. Ramsay, LL.D., F.R.S., 5th ed., 1878, chap. xvii., p. 270.

Digitized by Google

sluggish-running stream—could not possibly have done all the work attributed to it, while the Clyde had done so little. He was also of the opinion that the dyke crossing the Clyde near Elderslie, and generally known as "the Elderslie Rock," which had cost the Clyde Trust many thousands of pounds to blast away during their operations for deepening the channel, was certainly continuous across the valley from the hills on one side to those on the other, as the river would never have tried to make its way across such a barrier if a passage had been available through any softer material—clay, sand, or gravel.

In 1876 the late Mr. Robert Craig read a paper to the Society on the Arkleston Dolerite Bed,* with a number of particulars as to its crossing the Clyde furnished him by Mr. Deas, engineer to the Clyde Trust. Bores put down on the north side of the river showed that the bed extended northwards with a dip in that direction.

Of these various theories I am inclined to favour the third —the river one—although as we have no ascertained data regarding the termination of the narrow channel (or gorge as it would then be) at Bowling, we cannot come to any definite conclusion. Of course, this theory involves the admission that there must have been a rise in the land of more than 300 feet, but this need not be any real drawback to its adoption.

How the Hollow was filled up.—Mr. James Bennie's very interesting paper on "Surface Geology," already quoted, shows that this great east and west hollow was filled up by several successively-deposited thick beds of Boulder-clay, separated, underlaid, and overlaid, by beds of sand, clay, and gravel, all of which had been deposited under water. The thickest of these Boulder-clay beds is one near the river Carron, reaching 157 feet, but none on the western side exceed 100 feet. Even more interesting are the dividing sands, clays, and gravels, which separate the Boulder-clays, by as much as 133 feet in one case, and supply us with some evidence in favour of the so-called interglacial periods. If the marine origin of the Boulder-clay is accepted, these might be accounted for by a simple diversion of the ice-laden currents.

* "Remarks upon the Bed of Dolerite which crosses Renfrewshire to the east of Paisley"—*Trans.*, vol. v., part ii., 1877, p. 270.

Digitized by Google

Towards the latter end of this glacial period came the time of local glaciers. Our esteemed member, the late Mr. Dugald Bell, advanced a theory (also claimed by Dr. James Geikie, although he admitted that Mr. Bell had the priority of publication) that a great glacier had come down Loch Lomond, and, crossing the Clyde, had jammed itself against the Renfrewshire hills, damming back the waters of the Clyde until they rose sufficiently high for their overflow to reach the sea by way of the Garnock Valley, at a height of about 120 feet above the sea-level of the present time.

This is a grand theory, and if poetry or romance could be adduced as arguments in its favour, it ought to be true. Taking one's stand, say, on a hill near Old Kilpatrick, this great ice-dammed lake, filled in its hill-surrounded circle with the waters of the river which flowed through yon far-off hollow, can be conjured up in the mind's eye. Yet I cannot accept it as a fact, for the very prosaic reason that I know of no evidence of any kind to support it. I do not know of any traces of a large river like the Clyde having flowed down the Garnock Valley, nor of any Raised-beaches, nor "Parallel Roads" (as in Lochaber), corresponding with the height of the "col" where its waters escaped to the Ayrshire coast. We might have expected to find a lateral moraine in the neighbourhood of Dumbuck, though as even Mr. Donnelly has failed to find one, I may be excused for not having done so either.

At a time probably immediately succeeding the period of local glaciers, there seems to have been a marine channel between the North Sea and the Firth of Clyde, through which passed a strong current, carrying icebergs which scraped the bottom, and left the many elliptical eminences, with their long axes running east and west (known as "drums"), and also those many minor ridges which run like great waves all in the same direction. As the Boulder-clay comes to the surface near Dumbuck, it follows that the overlying beds would be deposited in a hollow filled with salt or fresh water according to the relative level of the land and sea at the particular period.

As the glacial period gradually passed away this landlocked area remained covered by the sea, then much colder than it is now, as we know from the glacial character of the shell-beds for which this district is famous. These are found as far up

Digitized by Google

the Clyde valley as Paisley, and also, though very sparingly, at Kingston Dock, Windmillcroft, Glasgow. At this time the land probably stood very much lower than it does at present, for many of the shells in these beds are characteristic of deep water conditions. Traces of the more recent Raised-beach shells are much fewer, the depth of water in which they lived being probably much shallower. They have been found as far up the Clyde Valley as the western suburbs of Glasgow, but no traces of them have been met with in the thick beds of brick-clays, laminated clays, and sands, which abound further to the east. The whole evidence seems to point to the conclusion that, like the Lake of Stennis, described by Hugh Miller,* the lower end of the estuary was marine, while the upper end was brackish or fresh-water.

THE PERIOD OF EMERGENCE.—Then came the period of emergence, when the land rose gradually from the sea, with pauses at wide intervals at certain levels, leaving in evidence the various Raised-beaches, which, from about 100 feet above present sea-level downwards, are found round our coasts. How long these conditions lasted, and how extended were the stops, we do not know, but Smith of Jordanhill,† by comparing the differences between the denudation of the sandstone and that of the trap at the Keppel dyke near Millport, came to the conclusion that the land had remained at the level of the 25-feet beach about sixteen times as long as it has remained at the present level. Thus, if 2000 years represent the minimum period at which the land has stood under present conditions, then the formation of the 25-feet beach may have taken 32,000 years.

Man is supposed to have made his first appearance when the land stood some 25 feet lower than it now does, and to have sailed his dug-out canoes over the waters covering the area where now stands a large portion of the City of Glasgow. The occasional discovery under the streets of the more or less perfect remains of those ancient boats, far from the present channel of the river, and at levels which the highest floods now fail to reach, yields strong evidence in this direction. There is evidence to show

* "Footprints of the Creator; or, the Asterolepis of Stromness," 1861. "The Lake of Stennis," p. 1.

† "Newer Pleiocene Geology," p. 39.

Digitized by Google

that for some time, both before and after this last rise of the land, the local climate was warmer than at present. Some molluscs then living in the Clyde have since become extinct, although still possessing a British habitat further south. To this class belongs *Trochus lineatus*, found in the Raised-beach near Tan Point, Cumbrae. It must have been plentiful, for it was used as food by early man, its remains having been got in the shell-mound beside the ancient rock-shelter at Ardrossan, described by Mr. John Smith in the *Transactions*.*

As for the period when the last elevation of the land took place there is no direct proof, yet it must have been some considerable time before the Roman occupation, as not only does the Roman Wall terminate at the Clyde in relation to the present levels, but there is on the east coast a ford across a river, and some other remains of Roman work, all observing similar conditions. Several grave-mounds containing urns and stone implements, and dating probably from long anterior to the Roman invasion, have also been built on the old Clyde sea-beach, *e.g.*, in the Cumbraes, and in Arran, where the large standing-stone by the roadside near Brodick school-house rests upon it.

The shell-mound at Ardrossan, referred to before, is also on this beach. Mr. Smith speaks of it as having been occupied immediately after the rise of the land, and considers it to belong to a period anterior to that in which flint arrowheads were used in Ayrshire. The remains of cave dwellers, found four or five years ago at Oban, were probably also on the same beach, and apparently belonged to a similar age with the Ardrossan ones.†

CAUSES OF THE CHANGES OF LEVEL.—These are not to be found in movements of the older rocks, on which the clays, gravels, and sands of Post-Tertiary times rest. Since the later Tertiary period the land seems to have remained nearly, if not quite, stationary, and there are either no faults, dykes, contortions, or movements, or they are so very small that they have not been noticed, so far as I am aware. The earthquakes we have occasionally read of as

* "The Ardrossan Shell-mound, with an Account of its Excavation," by John Smith—*Trans.*, vol. ix., part ii., 1893, p. 355.

† "Notice of a Cave recently discovered at Oban," by Joseph Anderson, LL.D.—*Trans. Soc. Antiq. Scot.*, vol. xxix., p. 229, 1895.

Digitized by Google

having occurred in Scotland indicate earth-movements, probably of permanent change, but they are so slight that even their cumulative effect during thousands of years has not been great enough to attract notice, and they therefore may be taken as infinitesimal, and the causes must be looked for elsewhere.

Nor were the changes due to local causes. Had this been the case the effects would also have been local. But not only are these changes observable all over Britain, over Europe, and the southern shores of the Mediterranean, but probably, also, over the whole of the Northern hemisphere, necessitating a cause of equally wide-reaching influence.

The only other cause which I suggest might have effected a change of level is an alteration of the Earth's centre of gravity. Let us suppose this to have been shifted, then the waters would follow it, for the lowest part is always that nearest this centre, and it would be submerged by waters which left other parts, then said to be elevated. This is, of course, modified by the centrifugal force due to the Earth's diurnal rotation, but taking meantime this latter as a constant, the argument holds good.

But any alteration of the Earth's centre of gravity is the effect of some other motion, of which there are various, viz. :—

The action of rivers. The majority of the rivers of the globe transport the debris they carry either in an east and west or in a southerly direction, so that a great mass of matter is being constantly shifted in those directions, which would cause elevation in the Northern hemisphere and submergence in the Southern. This, although its effects might be considerable, could not have been the cause of our Raised-beaches, as it is constant, while the beaches indicate a long rest with a comparatively quick change.

It was pointed out a number of years ago by Lord Kelvin (then Sir William Thomson, and president of the Society),* that a great accumulation of ice round the North Pole would cause the waters to flow in that direction, and thus more or less submerge the Northern hemisphere, the submergence becoming greater as the Pole was approached. Possibly to such a cause some, if not all, of our Raised-beaches might be due. There would be a melting of the

* "Polar Ice Caps and their Influence in changing Sea Levels," by Sir William Thomson, LL.D., F.R.S., &c.—*Trans.*, vol. viii., part ii., 1888, p. 322.

Digitized by Google

ice, represented afterwards by a change of level, and then a period of rest, shown by a Raised-beach; then a time of balance, with an equal amount of ice at the North Pole and the South Pole respectively. Perhaps the elevations, including that of the great continental period when the whole of Europe stood several hundreds of feet higher above the sea than it now does, might be due to some great piling-up of ice round the South Pole. That is the more probable, because there is every reason to believe that our climate was warmer then than now. This is the period in which palæolithic man is supposed to have first appeared on the scene, and may have antedated our oldest Raised-beaches.

Active Volcanic Forces.—Although we cannot point to any evidences of volcanic forces having been active in Scotland at this time, yet we know that they were in operation elsewhere, and any alteration of levels, either up or down, would, by shifting the Earth's centre of gravity, have an effect, not only upon the immediate neighbourhood, but also upon the opposite point of the Earth's surface, culminating at a place diametrically opposite to its own position. To whichever of these influences the changes of level may have been due, it is a mistake to describe them as "movements of the land"; for they were really movements of the water, the land no more having risen or fallen than it does during the ebb and flow of the tide. In the exercise of most forces there is a slight reflex or swing-back motion, like that of a clock pendulum, and it almost seems as if such a motion were traceable in some of these changes of level. It is a recognised fact that upheavals, due to igneous forces, are generally followed by slighter subsidences, due to the contraction of the rocks when cooling, and various phenomena in Scotland and in Switzerland are accounted for on a similar hypothesis.

The Dumbuck "Crannog."—We now come to consider the evidence bearing on the conditions under which this curious structure was built and occupied. The various points regarding it, even after all these years of heated controversy, do not appear to have reached any mutually satisfactory explanation. I do not at present refer to the various articles found during the excavation of the "Crannog," some of which differed from anything previously got in Scotland, but to the structure itself, which is submerged for about half of each tide, and when

Digitized by Google

left above water does not appear to have had defences of any consequence. The differences of opinion which arose in the course of its examination and of the objects found in it, evoked, as I have already said, many conflicting statements and opinions, which appeared in letters to newspapers, articles in magazines, and papers to Societies. From some of these I differ very widely, and I shall now therefore make some extracts, so that I may record my strong dissent from them.

In a communication made by Dr. Robert Munro, F.R.S.E., to the *Glasgow Herald*,* and afterwards reprinted in the *Reliquary*,† he says—"The occupancy of the Dumbuck 'Crannog' may be ultimately placed as late as mediæval times. It is probable that when it was built the locality would be under water, even at low tide." And again Dr. Munro says ‡—"I never cherished, and nowhere published, the opinion, that the upheaval of the West of Scotland, indicated by the 25-feet Raised-beach, was subsequent to the Roman 'occupation.'"

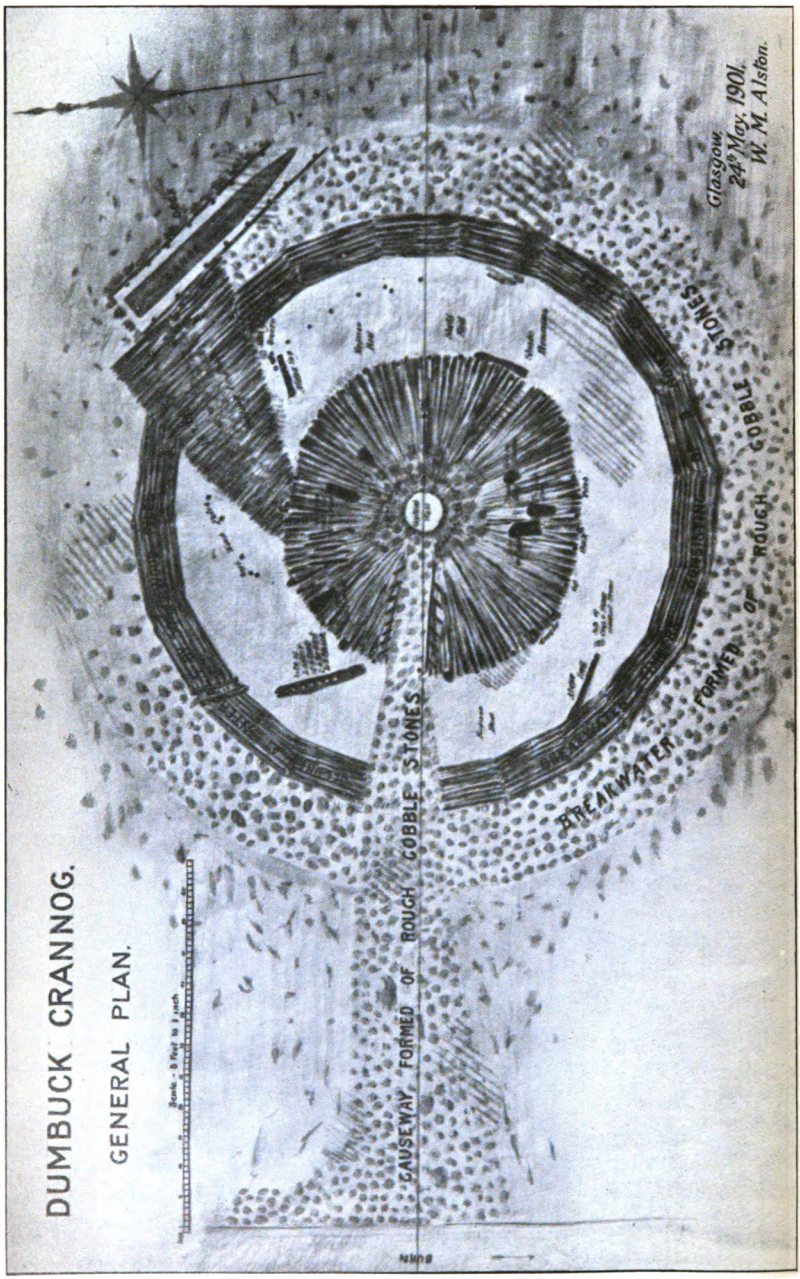
I find a difficulty in reconciling these statements. If I take the first two together, then the last rise of the land did not take place till mediæval times; and if I read the last two together then the "Crannog" was built in pre-Roman times; but both of these conclusions are denied by Dr. Munro. As to his remark that "the locality would be under water, even at low tide," I can understand how piles might be driven down, but not how the timber platform with its morticed joints could be made under water, nor to what use it could be put when made. Nor is it easy to see why a "dock" should have been made, the very top platform of which was always under water, nor to what use a "well" in a similar position could be put.

The truth is that the "Crannog" could not have been built, nor could it have been used even when built, if placed under water at low tide. Its very minimum height would be the present one; but even that raises great difficulties, for why should a large structure be built in a position where it must have been submerged for nearly twelve hours out of every twenty-four? Even if there was a top or upper storey to which access could be had by the

* *Glasgow Herald*, 7th January, 1899.
† *Reliquary*, for April, 1901, p. 138.
‡ *Ibid.*, p. 110.

Digitized by Google

Digitized by Google



Photolithed from Clyde Trust Plan by Hislop & Day, Engravers, Edin.

Digitized by Google

ladder, it would not be watertight, and might not even be safe during the winter storms; and we cannot imagine the possible use of a "well" (if it was a well) situated like the one in the "Crannog.'

After its discovery, the engineers of the Clyde Trust took great interest in the exploration of the Dumbuck "Crannog," and prepared plans and sections of the structure and its surroundings. To the principal one of these (of which a reduced copy is given, Plate VII.), they added the following descriptive notes:—

"The measurements taken for the construction of this Plan show that the Crannog consists of a central well or cavity, the sides being built of boulders lined with hazel wattle and blue clay. From this to a circle about 50 feet in diameter of oak piles, originally 27 in number, some of which are now removed, there is a floor composed of three layers of logs, the top and bottom layers radiating from a central well to a circle of piles, and the mid row running circumferentially. Round the well there is a rosette-shaped series of slightly raised stone mounds. Outside the above floored space there is a ring fully 20 feet wide, the inner 7 feet being of logs laid circumferentially and secured at intervals by soft-wood piles, and the remaining 13 feet being of rough cobble stones. The intervening space between the ring and the floored area had in it remains of various kinds, such as shells, shale and stone implements. At the N.E. side of the structure there is a dock about 40 feet long and 6 feet wide, in which was found a canoe, now removed. A timber-floored jetty leads to this dock from the circular area in the centre. Leading from the central well to the burn, about 120 feet to the west of the centre of the Crannog, there is a rough causeway composed of cobble stones. On the circular-floored area there are several large timber logs, having holes in them showing signs of burning, and evidently for the purpose of supporting stays."*

This Plan may be compared with the one in the *Proceedings* of the Philosophical Society (mentioned above) by Mr. Donnelly, who was the discoverer of the "Crannog." He has been accused of

* "During the measurements for this Plan, special excavations and cuttings were made at places ("harled") thus / / / /; the remainder of those parts covered by sand being filled in from general observations verified by probings."

Digitized by Google

exaggeration, to put it mildly, but I think that any one who takes the trouble of making the comparison suggested will admit the artistic excellence and close accuracy of his drawings, which, it must not be forgotten, were executed before those of the Clyde Trust engineers.

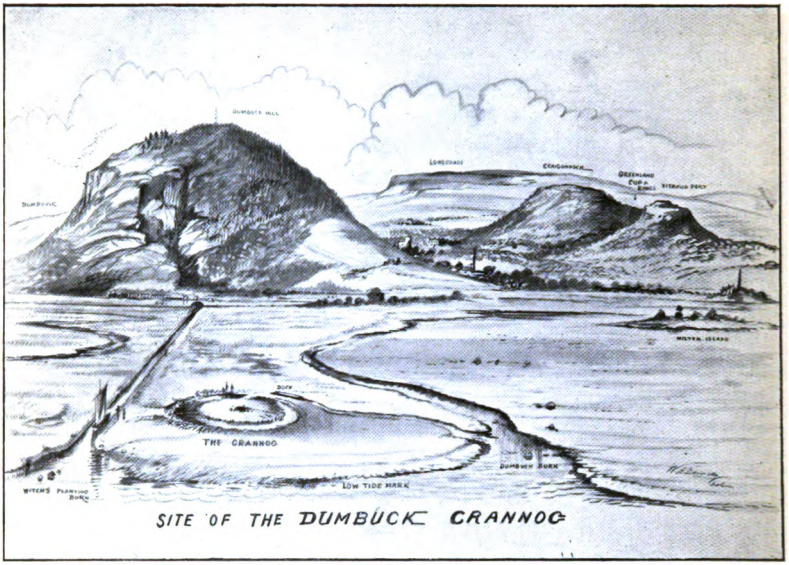
THE CAIRN OR BEACON THEORY.—Next as to the theory of Dr. David Murray, F.S.A.Scot., that this may have been the site of an ancient cairn or beacon, I would remark that, if this had been the case, surely the engineers of the Clyde Trust would have noticed it. There is not the slightest evidence to show that there ever was a cairn here. Dr. Murray has stated that the stones of which it was built were removed because they formed an obstruction to navigation; but so far as can be judged, if such an erection were standing on the spot at the present day, it would not be the least in the way of the river traffic. No traces of stones of which a cairn might have been built are now to be found, yet some stone structures of rosette form near the centre are still intact. All who have visited the structure must have observed how very soft and pulpy the various timbers of the structure were, a spade cut through the triple timber flooring as if it had been peat, while a wooden branch could be broken across like a twig. There can be no doubt that any considerable weight —such as a cairn of stones would have involved—would have crushed the platform and its timbers out of all recognisable shape.

Dr. Murray further remarks that "it is difficult to suggest why a pile dwelling should be placed on a spot dry for several hours every day. The so-called causeway would be under water at high, and of no use at low, tide. The supposed dock in which the canoe was found would be equally useless, being at one time on dry land, and at another 12 feet under water. The canoe does not seem to have been associated with the structure," &c.

This extract shows the difficulty of explaining anything if we take present levels only. But the "Crannog," the causeways, the "dock," are all there, and evidently were put to some use; and the great quantity of bones, including those of deer and wild boar, shows a considerable time of occupation. Regarding the "so-called dock," to quote again from the Clyde Trust Plan—"At the north-east side of the structure there is a dock about 40 feet long, by 6 feet wide, by 4 feet deep, in which was found a

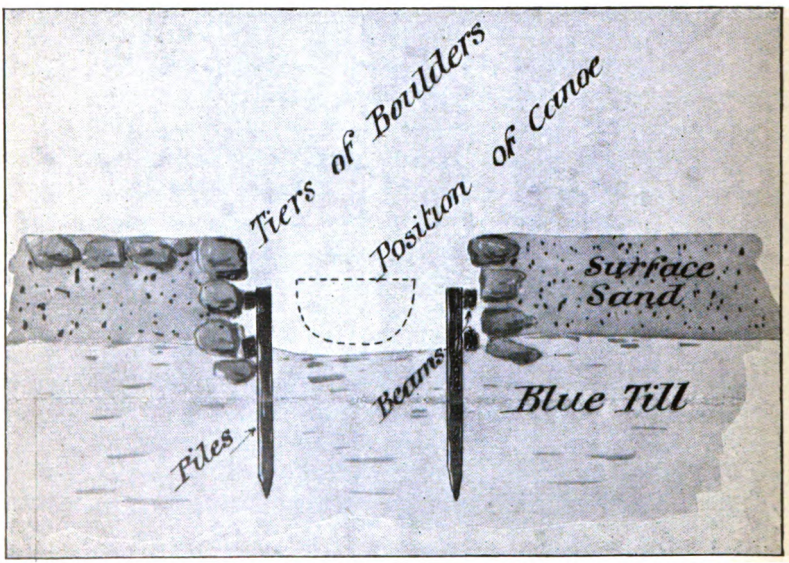
Digitized by Google

Digitized by Google



Hislop & Day, Photo-Engravers, Edin. *From a Sketch by W. A. Donnelly, 1903.*

No. I. The "Crannog" at ebb-tide, with Dumbuck Hill and Dumbuie behind, to the left. From half-tide the foreground is covered with water. The channel of the River Clyde is in the forefront.



Hislop & Day, Photo-Engravers, Edin. *W. M. Alston, 21st April 1905.*

No. II. Cross Section of the "Dock" in which the Canoe was found. Reduced from the Clyde Trust Plan.

Digitized by Google

canoe, now removed. A similar floored jetty leads to this dock from a circular area in the centre." The Clyde Trust engineers called it a dock, and they surely ought to know one when they see it. Another word, a "jetty," they imported into the discussion, Mr. Donnelly calls the latter a "causeway."

If the canoe had not been associated originally with the structure, it is, to say the least, very remarkable that it should have floated down and remained in a dock built hundreds, or possibly thousands, of years later. Possibly, as it would likely be tied to the dock, it pulled the whole thing away, and dock, jetty, and canoe floated down to where we now see their remains.

The desertion of the "Crannog" may have been due to the steady approach of some irresistible foe. It may have been dismantled, everything portable carried off, and the canoe filled with mud, and sunk in its own "dock." No enemy appears to have occupied it, as everything appears to have been kept intact.

On the other hand, the desertion of the "Crannog" may have been due to the sinking of the land to its present level, which rendered the structure no longer habitable. In that case, however, the canoe (which seems to have been in good and serviceable order when found) would likely have been removed, or have drifted away; or if waterlogged and silted up that it would have lain in the direction of the ebb tide, *i.e.*, *across* the dock, and not as found, *in* it.

THE AUTHOR'S SOLUTION OF THE PROBLEM.—What, then, is the solution of these difficulties which I have now to offer? This—that at the time the "Crannog" was formed the land may probably have stood at a higher level than it does at present. We may not think or speak so much of higher levels as of submergence, because the greater part of the evidence is under water, but there are many phenomena pointing in this direction. Our sea-lochs are simply the continuation under water of the glens at their heads, and such valleys undoubtedly owe their origin to river-gorges, formed when the land stood hundreds of feet higher than it now does. They have probably been deepened and widened by glacial action, the characteristic V-shape of the river-gorge being converted into the U-shape of the glacier-valley.

Digitized by Google

On various parts of our coasts submerged forests and peat-beds occur, and while some of these are undoubtedly older than the 25-feet beach, still some of them may not be so.* We have also several submerged beaches or terraces round our coasts, and references to some of those in the Clyde area may be found in the Society's *Transactions.*

One other matter which, I think, bears directly on this point is the fact that many of the rocks exposed along our sea-shores go sheer down into deep water. This denuding action of the sea seems to be mostly between tide-marks, and I have observed that in England, where the Raised-beach is not, or at least is not observable, the cliffs, many of them high and precipitous, which border the sea, have a beach at the foot, so that the great majority can be walked round from half tide downwards, while that would be impossible at high tide. This whole subject is very interesting, if somewhat difficult, and I would commend it to the attention of our members.

I believe that at the last rise (*i.e.*, after the formation of the 25-feet beach) the land was lifted several feet higher than its present level, and that it afterwards gradually sank to that at which we now see it. While not, of course, in a position to offer positive evidence on the point, I have for many years thought that the last movement of the land was downwards, and I have only hesitated to say so on account of the paucity of direct evidence, but the "Crannog" controversy has been the last straw, and I can now no longer refrain from stating my opinion for your judgment and criticism.

I can conceive of no possible use to which the "Crannogs" in their present position could be put, and the greater part of the bitterness of this controversy may have arisen from this cause. But, taking all the circumstances into account, both geological and archæological, this seems to me to be the most probable explanation. What would then be the position of matters at the "Crannogs"? That would depend on their position with regard to the ford, which existed in this immediate neighbourhood, and, down to the time when the river began to be deepened, had only some two feet of water over it at low tide. Previous to

* See "Post-Glacial Beds at Dundee," by James Durham, in the *Geological Magazine*, 1903, p. 306, where two forest-beds are described.

Digitized by Google

the Clyde Trust deepening operations the ebb tide was not as low as now. An old plan shows that in 1758 the low water line was 3½ feet above that of 1880, so that the "Crannogs" would then be always nearer the water, and more insulated than at present.

No matter how much higher the land may have stood, the river level relative to the "Crannogs" would be the same, and if they were above high-tide mark, then they would have only the river floods to contend with. This fact might also explain the reason of the "dock" being required, *which could be used at any time.* The position of the "Crannog" is on a fork between two small streams, which either were naturally deep enough or possibly may have been artificially deepened, to afford protection, and a cross cut between the two would convert it into a small island.

The present channel of the river is due to the scouring-out action of the water since the last rise of the land. If the "Crannog" was built shortly after the land rose there would at that time be no channel to confine the flow of the river, and its waters may have spread about a mile across the whole of the flat ground, from shore to shore, forming a sluggish stream, or in some parts a swampy marsh with reeds and rushes, from amongst which the "Crannog" might stand out as an elevation. If, as is likely, the mud between the "Crannog" and the shore has been deposited since the rise of the land there would be none when it was erected, and so it would stand relatively higher than at present.

It has been objected to the very early date to which I would consign this structure that Crannogs belong to post-Roman times. But, on the other hand, we have been told on good authority (Dr. Munro and others) that this is not a Crannog at all, and in Mr. Bruce's paper referred to it is spoken of as a "pile structure." If not a Crannog the fact that such structures are post-Roman is quite irrelevant. It may, however, be the original form from which in course of time the true Crannogs were developed.

Although the Dumbuck "Crannog" is the outcome of a great deal of rude skill and labour, yet its defences are poor compared with those provided by nature in the rocky hills close by, from the heights of which every action of its inhabitants could be seen

Digitized by Google

and noted, and its chief use may therefore have been that of an outwork belonging to the people who held the heights.

To conclude, it is very difficult, indeed, to see any sufficient reason for these curious structures—the Clyde "Crannogs"—having been placed in their present position; but I trust that the present paper may have thrown some light on the many interesting, if somewhat perplexing, problems which have arisen out of their discovery.

Bibliography.

1899. "Report of a Conjoint Visit of the Geological and Philosophical Societies to the Dumbuck Crannog," 8*th April*, 1899. By John F. Campbell. *Proceedings* of the Glasgow Philosophical Society, vol. xxx., 1899, p. 267.

1899-1900. "Notes of the Discovery and Exploration of a Pile Structure on the North Bank of the River Clyde, East from Dumbarton Rock." By John Bruce, F.S.A.Scot., Helensburgh. *Proceedings* of the Society of Antiquaries of Scotland, vol. xxxiv., 1899-1900, p. 437.

*** This is the official Report of the investigators, and embodies the Report read by Mr. Bruce before the Helensburgh Natural History and Antiquarian Society.

1900. "On Ornaments of Jet and Cannel Coal, on Cup and Ring Markings, and on Slate Weapons, as characteristic of the Neolithic Age." By Rev. H. J. Dukinfield Astley, M.A. *Journ. Brit. Archæol. Assoc.*, June, 1900.

1901. "Some Resemblances between the Religious and Magical Ideas of Modern Savage Peoples and those of the Prehistoric Non-Celtic Races of Europe." By Rev. H. J. Dukinfield Astley, M.A. *Journ. Brit. Archæol. Assoc.*, September, 1901.

1904. "Portuguese Parallels to the Clydeside Discoveries." By Rev. H. J. Dukinfield Astley, M.A. *Journ. Brit. Archæol. Assoc.*, 1904.

1905. "Report of and Investigation upon the Langbank Pile Dwelling." By John Bruce, F.S.A.Scot. *Transactions* of the Archæological Society of Glasgow, new series, vol. v., part i., 1905, p. 43.

Digitized by Google

1899-1905. A Series of Letters and Articles in the *Glasgow Herald.* By Contributors and Correspondents.

1899-1905. A Series of Letters and Articles in the Glasgow *Evening Times.* By Contributors and Correspondents.

1905. "Archæology and False Antiquities." By Robert Munro, LL.D., F.R.S.E., F.S.A.Scot. London, 1905.

Digitized by Google

No. XXXIV.—The Structure of Igneous Rocks. By Frederick Mort, M.A., B.Sc., F.G.S., Demonstrator in Geology, Glasgow University.

[Read 14th January, 1904.]

Summary.

The author stated that his intention was not to present any results of original investigation, but to collect and arrange the information on the subject that is at present only to be found scattered through various books and memoirs.

The only structure on the large scale to be considered was "columnar jointing." This is undoubtedly a phenomenon due to contraction, and is dealt with in detail by Scrope, "Volcanoes," 1862; J. J. Thomson, "*Trans.* Belfast Nat. Field Club," 1869; Mallet, *Philosophical Mag.*, 1875; and Bonney, *Quarterly Journal of Geol. Soc.*, 1876. The first explanation of the cause of this phenomenon is generally attributed to Scrope, but it is interesting to find that the illustrious James Hutton, of Edinburgh, anticipated Scrope by eighty years.

In the third volume of Hutton's "Theory of the Earth," recently printed by the London Geological Society from the manuscripts in its possession, it is stated (page 230) that, "By this it will appear that the cracks . . . had been begun originally in the cooling or contractions of the mass." Again (page 228), Hutton refers to "the regular contraction or basaltic cracking of the mass in cooling."

Following the mathematical method of Mallet, it is easy to see that a plane surface can only be completely subdivided (leaving no intervening spaces) by three regular figures, the equilateral triangle, the square, or the hexagon. The force required to produce a crack is proportional to the length of the crack, and for equal areas the perimeter of the hexagon is least, therefore there is least work required to produce hexagonal cracks, therefore hexagonal cracking will result. The reasoning is strengthened by considering the directions of the tensions

Digitized by Google

produced by contraction. With hexagonal cracks these act more nearly at right angles to the cracks than in the other two cases. Therefore, for this reason also, hexagonal cracking is the easiest to produce, and should therefore be most commonly found.

The author then described a large number of the structures of igneous rocks as seen under the microscope, and described the conditions that were necessary to produce them. The paper was illustrated by a large series of photographs and photo-micrographs shown by the oxyhydrogen lantern.

Digitized by Google

No. XXXV.—The Highland Boundary Fault in Arran. By James Stark.

[Read 11th February, 1904.]

Summary.

The Highland Boundary Fault strikes the north-east coast of Arran near the Fallen Rocks, where, instead of continuing its normal south-westerly course, which would take it right across the granite mountains which form the nucleus of the island, it turns to the south and south-east, and describes a semicircle concentric with the granite, till it disappears under the Sound of Kilbrannan at Dougrie. Here the fault appears to resume its normal direction, reappearing near the Mull of Kintyre, and passing on into the north-east of Ireland. Tracing the fault across Arran from the north-east, we find that for the first two miles its direction is nearly due south, and the quartzite conglomerates of the Lower Old Red Sandstone lie uptilted against nearly vertical schists, some of which, from the presence of cherty bands associated with lavas, somewhat resembling the Arenig rocks of the Southern Uplands, are suggested by the Geological Survey to be of corresponding age. The schists are cut out on the north side of Glen Sannox, and for the next three miles the Lower Old Red lies directly against, and has been greatly indurated and altered by contact with the granite. The schists reappear half a mile to the north-west of the summit of Maol Don, and from this point right across to the western shore of the island form a narrow strip, bordering the granite on the one side and having the Old Red faulted down against them on the other.

The intrusion of the granite has, of course, nothing to do with the tilting of the schists and the Old Red Sandstone to their present high angles, but both the strike of these rocks and the course of the fault appear to have been profoundly modified by that event. To the south-east of the granite area, in the neighbourhood of Brodick, and also on the north-west, between Loch Ranza and Caticol, the strike of these rocks still maintains, in great measure, its original south-westerly direction. To the north of the granite, however,

Digitized by Google

from the boundary fault westwards to Loch Ranza, the strike varies from south to south-east, which would seem to indicate that in this district the schists had been stretched and thrust outwards from the granite, and the strike shifted, so that in North Sannox Glen it is due south, while in Glen Chalmadale it is south-east, in the former case abutting on, and in the latter normal to the granite margin. All round the west side of the granite the schists have been most powerfully affected by its intrusion, and their strike is almost everywhere concentric with the granite margin. The granite, indeed, appears to have been intruded nearly or quite on the line of the fault, and was probably at the time of its intrusion, at least round the exterior of its mass, not in a fluid condition, as it has forced up with it the schists which underlay the Old Red rocks on the south-eastern side of the fault, and stretched and shifted them towards the east, compelling the line of fault to shift with them, and take up a new direction concentric with the disturbing granite. It seems difficult to understand how this could have been accomplished had the granite been in a perfectly fluid condition. At the same time, it was doubtless at such a high temperature as to become fluid whenever the superincumbent pressure was in any way relieved. Hence we find that wherever the surrounding schists, or any portion of the granite itself, yielding to the enormous strains to which they were subjected, opened into fissures, the granite in the neighbourhood immediately liquefied, and was injected into the fissures, forming veins and strings, which consolidated too rapidly to admit of the crystallising out of its component minerals.

Although the granite has thus been intruded in the line of the fault, there is no evidence that it there found vent at the surface, but as it is separated by a distance of less than a mile and a half (on the present surface) from the smaller granitic area to the south of the String Road, which was undoubtedly the vent of a great volcano in Tertiary times, there seems good reason to believe that the two masses are connected underground, and are both portions of the same deep-seated reservoir from which that volcano was fed.

Digitized by Google

No. XXXVI.—Notes on a Section seen in a Drain on the Lands of Davieland, near Thornliebank. By James Neilson.

[Read 14th April, 1904.]

The drain in question runs parallel to the road which leads from the west end of Thornliebank to Clarkston, and about 50 yards south of the same.

It was pointed out to us during an excursion of the Glasgow Geological Society in November, 1903.

The specimens referred to were taken from a point about 200 yards east of the boundary of the Rouken Glen Park.

Unfortunately it was dusk ere we arrived, and we could only secure a few specimens.

I made another trip a few days later, only to find that the drain was being filled up, and, what between the slush and the men working in the hole, I was unable to get the proper section or to secure enough specimens to piece together what I consider one of the most interesting bits of local history that has turned up of late years.

The best section I saw was something like the following:—

		Feet.	Inches.		Feet.	Inches.
Arden Limestone, - -	from	0	0	up to	3	0
Marine Shale (guess), - -	,,	2	0	,,	3	0
Posidonimya Shale (guess), -		0	2	,,	0	6
Shale (guess), - - - - - - - -					3	0

Total, about 8 or 9 feet.

Most of our Marine Limestones have a bed of coal lying at a short distance underneath, and the Arden is no exception to this rule, although it was not seen in this section.

The Arden Limestone has been extensively wrought in this district for many years, but as the work ceases at the bottom of the Limestone I have never before seen these shales exposed.

Our late respected Vice-President, John Young, LL.D., however, recorded the finding of these shales in a drain at Arden Old Limestone Quarry, about a mile west from here. This was recorded in the year 1865, and the drain was shortly after-

Digitized by Google

wards covered up, and, so far as I am aware, has never been observed from that time (see *Trans.*, vol. ii., 70-1).

These same beds may be seen exposed in natural section at Linn Spout, Dalry, and are described by Mr. Robert Craig in the *Transactions*,* the section being as follows:—

	Feet.	Inches.
Limestone (Upper Linn),	35	0
Shale (very fossiliferous),	5	9
Limestone,	1	0
Shale (full of *Estheria punctatella*),	0	8
Limestone,	1	2
Shale (indurated)	1	3
Coal,	from 2 feet to 5 feet.	

The lowest bed exposed in the drain at Davieland is a dark, slightly carbonaceous shale. It readily splits into thin, smooth, parallel slabs. Mr. Young calls it "Alum Shale," but my attention not having been directed to this I am not in a position to make any comment.

Overlying (?) this shale is another which contrasts with it very much, especially in that it is charged with fossils, so for want of a better name I call it meantime the "Estheria Shale," because of the prevalence of two shells formerly referred to that genus, and one of which I meantime retain the name.

Unfortunately I cannot give its thickness. The specimens I have do not show more than about 2 inches. At Linn Spout this shale is 8 inches thick, but I am inclined to think it is less here. It undergoes rapid deterioration (which affects also the contained fossils) through exposure to the atmosphere. Mr. John Young speaks of it as an alum shale, and probably its rapid deterioration may be due to the action of that salt.

I cannot even tell from my specimens which is the top side, the only means I have of judging being some two or three pick marks, and if these have been struck while the slabs were in position that would show the top side. The shale splits easily into thin slabs, in which are thin lines of fossils. The peculiarity of these specimens is that the fossils suddenly appear in enormous numbers in thin zones, then within a short space (1-16 of an inch or so) these fossils suddenly and entirely

* "On the Upper Limestones of North Ayrshire, &c."—*Trans. Geol. Soc. of Glasgow*, vol. viii., p. 28.

Digitized by Google

disappear, and are replaced by a barren zone 1-16 inch to $\frac{3}{8}$ inch in thickness. Then occurs another fossil band, also about 1-16 inch thick, but filled by entirely different fossils, followed by another barren zone, and so on.

One of the specimens exhibited shows 5 life zones with the 4 barren zones, all within a space of $\frac{1}{2}$ inch.

These may be numbered as follows:—

1st. *Posidonimya Youngi* zone.

2nd. *Posidonimya Youngi*, &c., zone.

3rd. Fish (*Acrolepis Hopkinsi*) zone.

4th. *Posidonimya punctatella* (small size) zone.

5th. Marine Fry zone, mostly *Actinopteria* (*Pteronites*) *persulcata.*

From other specimens I conclude that there is probably more than one zone of *P. punctatella* (small size) and of marine fry, and these are underlaid (?) at a distance of about $\frac{3}{8}$ inch by a zone of

6th. *Posidonimya punctatella* of very large size up to $1\frac{3}{8}$ inch by 1 inch.

There is still another zone, that of

7th. *Lingula squamiformis.*

It is situated within $\frac{3}{8}$ inch of a zone of *P. punctatella* (small), but which or where I am unable to say.

8th. Overlying all there is the marine shale, which does not split, but breaks up into irregular pieces, and is charged with all the usual characteristic marine forms, among which the brachiopods, *Productus* and *Athyris*, are the most common.

Posidonimya Shale.

The first mention of this shale is in a paper read by the late Dr. John Young before this Society on 13th April, 1865,* where the principal fossil is described by Professor T. Rupert Jones under the name of *Estheria punctatella*, on account of certain minute shell structure which he considered characteristic of Crustacea.

Again, on 13th March, 1890, another notice appeared in the *Trans.*,† in which Professor Jones alters the genus from

* *Trans.*, vol. ii., p. 71. † Vol. ix., p. 79, and plate v.

Digitized by Google

Estheria to *Posidonimya* (a bivalve mollusc), and also describes *Estheria Youngi* as a crustacean.

It is to be noticed that the shale from which this latter shell was described had been in Dr. Young's possession for more than twenty years. Owing to deterioration the fossils could not be so well seen as in the fresh specimens now produced, and there is reason to think that it also is a mollusc, and probably belongs to the same genus as the preceding.

Professor Jones has also referred to these shells while describing some Siberian specimens.*

Dr. Young speaks of *Estheria punctatella*† as having been got in alum shales at Campsie and in an aluminous shale at Braehead, near Busby. I know Braehead pretty well, but have never observed anything resembling it there, nor does Dr. Young ever mention that locality in any subsequent publication, so I presume it may be dismissed.

In Young and Armstrong's list, 1871,‡ the following localities are given for *Estheria punctatella:*—Arden in alum shale; 1st Kingshaw Limestone, Carluke; South Hill and Glorat, Campsie, in alum shale.

In the "Catalogue of Western Scottish Fossils," 1876 (compiled for British Association by James Armstrong, John Young, and David Robertson), the three latter localities are dropped out, and the localities given are Arden and Linn Spout, Dalry.

This, however, does not necessarily mean that the authors had abandoned those other localities, as pressure was brought to bear by the Committee of the British Association to keep the book down to the smallest possible limit, which was done by omitting the localities.

This course was also adopted in the 1901 British Association Catalogue, and constitutes, in my opinion, the greatest defect of these books, which for zoning purposes are of comparatively little use, and certainly will never supersede the Catalogue of 1871.

Again, in 1890,§ the localities given are Arden and Linn Spout, while in "The Geology of the Campsie District," by Dr. John Young, 3rd edition, 1893, none of these *fossils* are given.

* *Geol. Mag.*, 1901, p. 434. † *Trans.*, vol. ii., p. 72.
‡ *Trans.*, vol. iii., appendix, p. 30. § *Trans.*, vol. ix., pp. 80 and 84.

Digitized by Google

I understand that no specimens from other localities are in Dr. Young's collection (now in the Kelvingrove Museum, Glasgow), and, as Mr. John Smith says he knows of none, I think we may take it as proved that the only known localities for these shells are Thornliebank and Linn Spout.

As these localities are on one geological horizon, we are faced by the interesting fact that these shells suddenly appear in myriads on this horizon, and after flourishing for a very short period are as suddenly cut off and disappear, so far as we know, for ever.

This seems to traverse all our ideas of evolution and development, as, according to these, there ought to be a slow transition from allied forms, and when a comparatively stable form had been reached a considerable time ought to elapse before the shell grew so numerous as practically to monopolise the whole bottom of the water, as we see this does. Yet the whole happens so suddenly that within a space of time measured by 1-16 of an inch, the shell has appeared and disappeared, and, after two or three alternations, disappears, so far as we know, for ever. There were doubtless places outside the area of our observations where it developed and where it survived during these barren intervals, but these are, in the meantime, at least, "missing links."

The *Estheria Youngi* and the smaller form of *P. punctatella* cover the surface so completely that often the shale itself is not seen at all. The larger shells are not quite so closely packed. There is, however, no appearance of any other organism in the same layer.

It seems to us that these shells indicate fresh-water conditions, of which the above monopoly is characteristic, and this seems also to have been the opinion of Mr. Young and Professor Rupert Jones, as *Estheria* is a distinctly fresh-water genus.

Zone No. 3—Fish Zone.—So called because it contains numerous bones, scales, and teeth of Ganoid fishes, among which *Acrolepis Hopkinsi* has been identified. I am also under the impression that this represents fresh-water conditions. As the distance between Zones 2 and 4 is only about $\frac{1}{8}$ inch, some of the fish remains appear as touching each of

Digitized by Google

these zones, but I am of opinion that they formed a distinct zone, in which none of the inhabitants of Zones 2 or 4 lived.

No. 5—Marine Fry Zone.—There appear to be several of these. The surface is charged with the fry of marine Lamellibranchs, mostly from under 1-16 inch to about $\frac{1}{8}$ inch in length. Scattered among these is a number of minute spiral shells, probably belonging to the Murchisonia group, and also a number of straight shells, probably *Orthoceras*, some of these being of much larger growth.

The most interesting shell of this group is, however, a small one, formerly known as *Pteronites*, now *Actinopteria persulcata* (M'Coy), which occurs in hundreds to the square foot. The peculiarity of this shell is that in its young state the posterior portion of each valve is only very slightly calcareous, or possibly membranous, and is not preserved in a fossil state, so that the long rib forming the hinge line appears like a handle to the shell, the whole looking like some peculiarly shaped axe or one-sided harpoon.

As the shell grows in age this gap fills up, and we know it as *A. persulcata* M'Coy.

In my opinion these zones represent a period during which the sea broke into this hitherto confined fresh-water space, carrying with it the fry of a number of marine species, which at that age are free, and either float or swim. These conditions lasted only a very short time, not long enough to allow of these fry reaching maturity, and were again replaced by fresh-water conditions. There are, however, several specimens of *Orthoceras*, which certainly are not fry, but then it has to be remembered that this species, like our modern cuttle fish or octopus, was a powerful swimmer, and probably came here in pursuit of the smaller animals.

As showing that the water at this time was rather inclined to be brackish, it may be mentioned that the more intensely marine types—Brachiopods, Encrinites, and Corals—are conspicuous by their absence.

Zone No. 6—Characterised by *P. punctatella* of very large size up to $1\frac{3}{8}$ inch by 1 inch.

These are not so thickly crowded together as the smaller size, yet they cover something like two-thirds of the entire surface of the shale. If, as I take it, this is older than Zone 4,

Digitized by Google

then the shell must have been at its best at the first, and suffered a period of deterioration before Zone 4 appeared. How far this deterioration continued I cannot say, but it is quite possible that *P. Youngi* may be a further deterioration in the struggle for existence before final extinction. Should this not be the case, then it is probable that the two species may have had a common ancestry.

Zone No. 7—Characterised by the presence of *Lingula squamiformis* of fairly large size.—This is a truly marine brachiopod shell, but possesses the peculiarity that it does not thrive under intense marine conditions, but thrives best in brackish water, and in our own beds a very interesting life history could be traced, marked by the diminishing number of associated marine forms as the water became fresher, until it attains its greatest size in the fossil series, in water so fresh as to kill off every other marine form, yet not fresh enough to permit of the existence of fresh water forms of life. In the present instance it is associated with one or two small marine forms and two small specimens of *Posidonimya*.

The mode in which the above fossils are preserved is somewhat puzzling. They are all pretty much crushed, yet the exterior has been so well preserved that the minute shell structure can still be traced. Yet, although in numerous instances the interior of the shell is exposed, this appears to have been partly dissolved away, so that now no details of the hinge nor of the muscle scars are preserved, so that the position of these so-called *Posidonimyas* is doubtful.

Dr. Young tells us they had already been referred to *Posidonia*, *Leptodomus*, *Sanguinolites*, *Estheria*, and now *Posidonimya*, but when next they appear in public they may be christened by a new name, but whether *Edmondia*, or *Carbonicola*, or some other name, time alone will tell. They will probably be refigured in Dr. Wheelton Hind's Monograph on Carboniferous Lamellibranchiata in the forthcoming number of the Palæontographical Society.

This remark as to preservation also applies to the *Orthocerases*, which are squeezed flat, so that it is only in rare cases that we can say whether they belong to that genus or to Dentalium.

Digitized by Google

I have never before seen *Orthoceras* in this state; the heavy siphuncle and strong septæ keeping this shell solid and circular in at least its smaller sizes. I am inclined to attribute this condition to the fact that the epidermis protected the exterior of the shell, while the interior was attacked by impurities in the water, and this theory is strengthened by the fact that *Actinopteria* has suffered least, being, as has been already shown, in a more cartilaginous condition than the others.

The fish remains are not in the least affected.

Having now worked out the details, let us ask, what is the story told by this section?

1st. The bed of coal—Tells of a land surface. It is generally considered that the coal trees grew where we now find the coal, and this shows that for a very long period this was either dry land or a sort of marsh. It is very strange, indeed, that nearly all our marine limestones are underlaid by a bed of coal, which is its very antithesis; this occurs too often to be considered as a coincidence, yet I cannot see how they can be regarded as cause and effect.

2nd. We have a long period represented by several feet of barren shale, in which the conditions were inimical to life. This was probably an enclosed lake charged with some salts.

3rd. Fresh-water conditions, with fossils.

4th. Barren zone, conditions inimical to life.

5th. The sea forces its way in, depositing minute fry; is again expelled, and again returns.

6th. Barren zone.

7th. Fresh-water conditions, *P. punctatella*, small size.

8th. Fresh water, but conditions changed; shells have disappeared, and only fish remains are found.

9th. Fresh water, *Posidonimya Youngi*, Zone 2.

10th. Barren zone.

11th. Fresh water, *Posidonimya Youngi*, No. 1.

12th. A period in which the sea returned and produced brackish conditions, evidenced by the *Lingula*.

13th. Marine shale—Truly marine conditions charged with life, but occupying some place not very far removed

Digitized by Google

from land, and near to some river, which brought down the mud in which the shells lived.

14th. Arden Hydraulic Limestone—A marine band near the estuary of some river, the fine mud from which, mixing with the lime deposited from sea organisms, &c., formed that cement-like character for which Arden Lime is known.*

The whole points to slowly sinking strata from dry land through various fluctuations to true marine conditions.

The *Posidonimya* bed has great persistence, having been recognised at Linn Spout, near Dalry, 18 miles away in a straight line, and is one of our most distinct beds, and as some of its fossils are confined to this bed, and very abundant in it, it is the best bed I know of for life zones. There has also been described from Linn Spout a large crustacean allied to *Dithyrocaris*, and named *Lebiscontia occulata Jones.* The specimen is in the possession of Mr. J. Smith, and is meantime unique.

It is, however, possible that I have described the series upside down, except the marine shale and limestone, which are undoubtedly at the top, in which case the reading must be reversed.

I have not in the present paper entered into the vexed question of lakes, lagoons, or estuaries, having already done so very freely in a paper on "The Calderwood Limestone and Cement Stone and their Associated Shales."†

Some points, however, I may refer to.

1st. The sea carries with it a very distinct (marine) fauna.

2nd. Estuaries contain this fauna, mixed with fresh water and land remains.

3rd. Fresh-water fauna is quite different from marine, and marine fossils are never got in fresh-water beds.

4th. There does not exist at the present day a third fauna, viz., one differing entirely from either marine or fresh water.

Note.—During the discussion which followed the reading of

* The substance known as Portland Cement is manufactured artificially from a mixture of chalk and Thames or Medway mud.

† *Trans.*, Glasgow Geological Society, 1893, vol. x., p. 61.

Digitized by Google

the above paper it was objected that there could not possibly be so many changes from salt to fresh water, as that would involve an incredible amount of oscillation of the crust at this point.

It will, however, be observed that I made no allusion to how these conditions were produced, for the simple reason that in a paper dealing with facts and deductions from these facts it is not advisable to introduce theories of which one can get no possible proof.

As, however, the point has been raised, I may state that it seems to me that all the phenomena may be accounted for by the theory of a slowly sinking area without any upward movement.

We first of all had land, represented by the coal, then we would have a swamp, and then later on a fresh-water lake. As the land continued slowly to sink, the barrier between the lake and the sea would become gradually lower and narrower, till some great tide, helped probably by strong winds blowing shoreward, burst over the barrier, carrying with it its marine fauna. As the waters subsided the lake would gradually become fresher again, and the marine life die and be replaced by the lake forms till the next incursion of the sea.

It is interesting to notice that at the present time the highest spring tides of the year occur about the period of the spring equinox, when the sea is charged with fry of all kinds, and it would be interesting to think that these minute shells represent the equinox in Carboniferous days.

As the land sunk still further the sea gained a permanent footing—represented by the marine shale, and as the land receded and the water became more pure the limestone was deposited.

Appendix.

I sent specimens of the shale to Dr. Wheelton Hind, who has redescribed and refigured the shell first named *Estheria punctatella*, and afterward *Posidonimya punctatella*, and has given it a third name, *Edmondia punctatella*.*

* Monograph of the British Carboniferous Lamellibranchiata, by Wheelton Hind, M.D., B.Sc.Lond., F.R.C.S., F.G.S.; vol. ii., p. 147, and plate xxv., figs. 12 and 13. London Palæontographical Society, 1904.

Digitized by Google

He says—"The generic affinity is doubtful in the absence of details of the interior, but the shells have none of the special characteristics of *Posidonimya*, and I am quite at a loss to account for their reference to this very distinct and characteristic genus. The shells are not oblique, and have no posterior winglike projection. For the present I place the species in the genus *Edmondia*, because there is no lunule and no escutcheon, and the hinge-line appears to be simple and erect. Whatever ligament there was seems to have been internal."

As I was inclined to regard *Estheria Youngi* as a mollusc, I was disappointed at no reference being made to it by Dr. Hind, but understand it was because none of the specimens were sufficiently well preserved.

Digitized by Google

No. XXXVII.—On the Modes of Occurrence and the Origins of Intrusive Rocks, with some Remarks upon the Formation of Eruptive Rocks in General. By. J. G. Goodchild, Curator of the Scottish Mineral Collection in the Edinburgh Museum of Science and Art.

[Read 5th May, 1904.]

Summary.

In the course of his paper Mr. Goodchild showed that terrestrial movements connected with changes of level of the earth's surface generate high temperature below the surface, as a result of the conversion of part of the energy of motion into that of heat, the resulting temperature being exactly proportionate to the energy expended. In the cases in which saline water, such as those of the sea or of inland lakes, finds its way to these subterranean zones of high temperature, suitable conditions are set up for the generation of earthquakes in the first instance, and then for that of volcanoes. From the surface of the volcano large quantities of steam are given off (as well as other gases), hence follows a gradual concentration of the substances dissolved in the water. These, in their turn, acting at high temperatures and pressures, begin slowly to dissolve the rock around and to incorporate the salts under consideration with the material so dissolved. In the cases in which the rocks so dissolved consist of a normal sedimentary aggregate, such as that forming the Lower Carboniferous Rocks of Central Scotland, the new compound would agree in composition with the Basalt-Andesite series of eruptive rocks, the lime-soda felspar, or the ferro-magnesian constituents preponderating, or not, according to local circumstances. The magma so formed at the focus of the volcano was partly expelled to the surface, and either welled out of the crater as a lava or was explosively discharged in the condition of pyroclastic rocks, such as tuff or agglomerate. Much of the remainder, forced upwards and outwards from the focus against

Digitized by Google

heavy resistance, slowly dissolved the rock around, and continued to do so as long as the requisite factors of temperature, pressure, alkalinity, and the presence of occluded $2H_2 + O_2$ remained in force. The cooled part of the dissolved material, partly under the influence of gravitation, slowly travelled back to the focus, there undergoing further digestion and assimilation. Then, charged with fresh stores of heat and additional alkalies, the assimilated materials were again slowly conveyed to the extremities of the system, where the corrosive magma dissolved more rock, which in turn was returned to the focus as before. Thus a gradual extension of the magma, further and still further from the focus, took place, cold, solid rock of one kind being gradually replaced by hot, fluid rock of another; when the requisite conditions ceased to act, the circulation gradually slackened down, and consolidation of the magma set in. Eventually the fluid rock passed into the solid state, and was left as either a crystalline or a hemicrystalline aggregate in the place before occupied by sediments.

It should be noted here that fluxion structure is a necessary consequence of this method of formation of eruptive rocks. Furthermore, the action of the alkaline solutions in the magma must necessarily produce some change upon the rocks contiguous to the intrusion, and in all cases both the nature and the extent of that change are regulated by the temperature of the country rock as compared with that of the magma. Where the difference is great the change (or thermometamorphism) must be small and limited in extent. Where, on the other hand, the country rock is at a temperature not much inferior to that of the invading magma extensive transfusion results. Intermediate conditions give rise to thermometamorphic effects in correspondence with these conditions.

It might appear at first sight to tell against the view that water has played so important a part in connection with the origin of eruptive rocks that so many of the phenomena of contact or thermometamorphism bear so close a resemblance to those which, it is thought, arise only through the direct action of "dry" heat. But if we carefully consider the subject in every light this difficulty is seen to be much less formidable

Digitized by Google

than it appears to be at first sight. The alteration of shales or clays into hard, flinty rocks, like adinoles, lydian stones, &c., and the change of sandstone into rocks with more or less of a quartzitic texture, are results exactly in accordance with what one ought to expect if heated alkaline waters operating under high pressure form the chief agent concerned. Such waters certainly dissolve silica, and their percolation through a shale or a clay could not fail to result in the silicification of these rocks. For the same reason the percolation of such waters through sandstone must result in a slight enlargement of the grains of sand, quite sufficient in many cases to fill up the interstices between the grains, and thus to impart the peculiar glistening lustre of the fractured surface which is to be seen on most sandstones altered by contact metamorphism.

Thermal waters charged with alkalies are said to be quite competent to produce the contact phenomena observed in connection with beds of coal that have been in contact with intrusive masses.

Digitized by Google

No. XXXVIII.—On Crystallised Carbonite, a Mineral new to Scottish Carboniferous Rocks. By John Smith.

[Read 2nd June, 1905.]

A short distance down the mineral railway from the sandstone loading bank at Sevenacres, Kilwinning parish, the Main Coal-seam crops out on the west side of the railway. Only a few yards of the outcrop is visible, and it apparently shows the full thickness of the seam, which at this part is seen to be traversed in different directions by trap, which has converted it into columnar carbonite for the most part. A thin "lid" on the top of the seam has assumed a massive structure, and between this lid and the columnar part there is a layer of crystallised carbonite half an inch thick, the thin crystals being brilliant like polished silver, and seldom more than one-eighth of an inch in diameter. They had evidently been formed when the coal was in a fluid state, from the heat communicated to it by the trap; but before the coal had solidified some movement had taken place in the fluid or semi-fluid mass, which had resulted in twisting the thin scaley crystals of carbonite considerably; still, generally speaking, the surfaces of the crystals are in the plane of the original bedding of the Coal-seam.

Other parts of the Coal-bed have got a few of the crystals.

The ordinary carbonite also occurs as little, more or less pear-shaped and spindle-like nodules, "electro-plated" (for want of a better term) with the brilliant form of the carbonite, the largest of them measuring 2 mm. in length; these little masses (like the rest of the "burnt coal") being vesicular, the vesicles often empty, but sometimes filled with calcite.

The plant structure has not in this carbonite been entirely destroyed by the heat communicated by the trap, and some of the vascular tissue shows up as bright-like as the carbonite crystals do.

Graphite, a form of carbon, crystallises in hexagonal tables, and I have made a special examination to see if I could find

Digitized by Google

any complete crystals of the carbonite. There probably were a few when the carbonite was originally formed, but I only saw some plates with two or three of the angles remaining.

I also examined the seam to see if I could find any pencil-graphite, but got none; so that the conditions for the formation of the carbonite crystals had been different from what they were at the time of the conversion of the Craigman Coal-seam by trap. In this seam abundance of pencil-graphite has been formed, but, so far as I have seen, no carbonite crystals were developed at that place.

When I first found this substance I was rather puzzled with it. I thought it must, of course, be graphite, but it did not stand the test for that substance; it is far too hard.

I sent a sample to the British Museum, with a request to know if it had been got any other place, and George T. Prior, Esq., has informed me that they have "a specimen of precisely similar material from Staffordshire; it is from Oakham New Pit, Rowley Hills, where dolerite has intruded into coal"; so that this substance appears to be of some rarity in Britain, and the Sevenacres outcrop is the only place where I have seen it.

In blast furnaces, when the finest quality of iron is being made, abundance of carbonite crystals, called by the furnacemen "keesh," are produced, and when a furnace is "running hot" carbonite crystals ooze out of the cooling iron and accumulate in little cavities on the surfaces of the "pigs"; of course, it soon falls out, leaving the surfaces in a carious condition, this quality of iron being called by the furnacemen "rotten rich." This gives a sort of clue to the temperature at which carbonite crystals are produced, at a pressure of, say, about 30 or 40 feet of ordinary rock, and temperature of about 2800° Fahr.; but in treating of substances formed at considerable depths below the surface (and at this place where the Sevenacres carbonite crystals occur nearly all the Coal-measures have been denuded off, and there may have been other formations above them at the time of the trap intrusion) pressure is a "quantity" which the geologist has difficulty in dealing with.

The little iron the coal has contained now shows in the form of hydrated oxide, which occurs in the joints and in gas cavities (some of it may have been introduced from the outside of the

Digitized by Google

seam) with a bright purple oxide, but in such small quantity as only to be seen with the microscope.

At the loading bank the same bed of coal occurs, but in an entirely different state, being a mass of compacted granular carbonite. At this part the coal is not traversed by trap, the latter here being a short distance below it. In this sooty-looking coal I found some years ago numerous minute crystals of quartz, with double pyramidal ends, which I exhibited to the Society. The largest of these little crystals is about half a mm. in length by about half of that in diameter, and a number of them are exceedingly small. The crystals also occur in little bunches or rosettes, and "sprouts" come off from both the ends and sides of some of them.

In the part of the coal with the carbonite crystals there are a few quartz crystals, but rather poor in shape and quality, while those in the granular carbonite are clear and brilliant.

The silica which formed these little quartz crystals in all likelihood came from the vegetation which went to build up the Coal-bed, at least there would likely be quite enough of it to do the job, and it is well known that certain kinds of plants contain a small quantity of silica, and the genial heat produced by the trap intrusion enabled them to grow.

At the place where the quartz crystals are in such perfection there are none of the carbonite crystals; evidently the heat here was not great enough to develop them.

Digitized by Google

No. XXXIX.—The Crystallisation of Rocks. By Frederick Mort, M.A., B.Sc., F.G.S., *Joint Hon. Secretary.*

[Read 12th January, 1905.]

To a greater degree than most branches of petrography the study of the crystallisation of rocks involves principles that are closely akin to those of physical geology. No geologist, therefore, hardly even the most rigorous specialist in palæontology, can afford to neglect the modern views regarding the origin of igneous rocks.

These rocks have all originated from reservoirs of fused material containing as important constituents various dissolved gases. Recent work has shown that this molten magma is best looked on as a mixed solution and applicable to exactly the same treatment as an aqueous solution—a view first put forward by Bunsen forty years ago. Diffusion, osmotic pressure, and ionisation must all be considered. We may even refer to minerals, such as the plagioclase felspar series, as solid solutions.

This magma is not a mixture of any substances whatsoever in any ratio, but certain substances are only present within certain limits, just as salts are in a solution. A magma containing a high percentage of silica always contains in addition a comparatively large amount of alkalies and a small amount of lime, magnesia, or iron oxide. This method of treating the magma as a solution is very helpful in explaining the perplexing order of crystallisation of the minerals of rocks. Quartz, which is very infusible, often crystallises last. But with watery solutions we know that the temperature of crystallisation varies with the amount of substance dissolved, and the same principle makes clear that the order of super-saturation, and thus of crystallisation of various minerals in a cooling magma, may be very different from the order of their fusibilities.

Some molten masses solidify before any crystallisation whatever has taken place. When this happens we get a rock glass, generally obsidian. In the pitch-stones we see the first beginnings of crystallisation. The Arran pitch-stone contains skeleton

Digitized by Google

crystals and dendritic and aborescent forms often of great beauty.

From such glassy rocks we pass by a continuous series through the hemi-crystalline to the granitic rocks, which are holo-crystalline.

As a general rule, in these rocks the first minerals to crystallise are the minor accessory ones, such as apatite, zircon, sphene, garnet, &c. Then follow the ferro-magnesian silicates, olivine, pyroxenes, hornblende, mica. Next comes the felspathic minerals and, lastly, quartz and microcline. There are one or two interesting exceptions to this rule. In many dolerites the felspar crystallises out before the augite, large plates of which enclose felspar laths, giving the ophitic structure. Again, in some rocks quartz and felspar crystallise simultaneously, giving rise to the familiar graphic or pegmatitic structure.

Igneous rocks are classified into plutonic and volcanic rocks, with generally an intermediate group of hyp-abyssal or dyke rocks. The plutonic rocks are characterised by a coarse-grained structure and an absence of a glassy or finely crystalline matrix. The minerals generally show allotriomorphic or hyp-idiomorphic outlines. The volcanic rocks are generally porphyritic, with a fine-grained or glassy base. The porphyritic minerals are generally idiomorphic.

The structure of the volcanic rocks is obviously the result of their extrusion at the earth's surface and consequent quick cooling. The plutonic rocks, including granite, syenite, diorite, gabbro, and some peridotites are generally supposed to have obtained their characteristic structure through their prolonged cooling under great pressure.

But instances are known of coarsely crystalline rocks that could not have been formed under such conditions. The quartz porphyry of the Alps [1] is in parts more than 3000 feet thick. The lower parts must therefore have been under a pressure of at least 90 tons to the square foot. The rate of cooling must also have been slow. Yet this rock presents all the characters of a true volcanic rock. It may be noted that Vallée Poussin, and Renard [2] calculated that the plutonic rocks of Belgium had formed under a pressure of but 84 tons to the square foot.

Again, a rock may crystallise under a small pressure, and

Digitized by Google

yet show a coarse granitic structure. An intrusion of molten material must cool more rapidly at its borders than at its centre, yet the exterior parts of many granites show a marked exaggeration of crystallinity.[3] Two local examples of this curious anomaly may be found in the Girvan district. The summit of the Byne Hill, two miles south of Girvan, is formed of granite. It is a moderately coarse-grained rock containing orthoclase and plagioclase felspar, quartz and mica, in fact, a typical granite. It belongs to a series of intrusions of Ordovician age, and there is definite evidence regarding the date of these intrusions. They are younger than many of the Arenig rocks, for they are intruded through them, but they are older than the next series, the Kirkland and Benan conglomerates, which are mainly made up of the igneous detritus.[4] Therefore it follows that since the igneous rocks were intruded before the next series was deposited, there cannot have been any great thickness of strata over them to cause the plutonic structure which is present.

Another local illustration is to be found in some of the basic dykes of the same region. One of these occurs on the shore one mile north of Lendalfoot. The rock is a hypersthene gabbro, consisting mainly of plagioclase felspar, green augite, and hypersthene. The dyke is only a few yards broad, yet it is more coarsely crystalline than most granites. Some of the felspars are as much as 1½ inches in length. In this case the conditions of solidification have been by no means plutonic. The rate of cooling has probably not been very slow nor the pressure very great, yet the structure is exceedingly coarse.

The most probable explanation of cases like these is based on the mineralising agents present in the magma. The mineralising agents may be water, water vapour, fluorine, chlorine, or boron compounds, or many other substances dissolved in the molten magma.

Daubrée seems to have been among the first to recognise the important part that mineralisers play in crystallisation. He showed the importance of fluorine in the production of mineral veins.[5] He produced cassiterite artificially at a temperature below its melting point.[6] In several experiments he showed the power that water has in influencing crystallisation. Since that

Digitized by Google

time many attempts have been made to produce minerals and rocks artificially, with particularly brilliant results in France.[7] These experiments make plain one striking fact, that it is impossible so far to crystallise certain substances without the aid of mineralisers. These refractory minerals, too (quartz, orthoclase, mica), are the very ones found in the granites and other acid rocks that contain the greatest amount of mineralisers.

Perhaps the strongest evidence of the action of mineralising agents is to be found in pegmatite veins.[8] These veins are generally formed of rock that is the most coarsely crystalline of any known to the petrologist. They are later than the main intrusive mass with which they are connected, and seem to have formed from the last dregs of the igneous magma in which the mineralisers have become more and more concentrated. Yet these pegmatites have almost certainly consolidated more rapidly than the much finer granitoid rock that they penetrate. There seems, therefore, to be no other explanation of the high degree of crystallinity and the presence of so many unusual minerals but the influence of mineralisers.

The importance of mineralisers is recognised by Mr. Harker in his recent description of the rocks of Skye,[9] in which he attributes the formation of amygdaloids in the basalts to mineralising agents, and not to mere weathering. Stead, in his important paper to the Iron and Steel Institute (1900), also notes that a very slight addition of phosphorus causes iron to crystallise in much larger grains.

The intrusions of the Girvan district present another interesting feature. If the Byne Hill granite is traced for some distance it is found to change gradually into a diorite, and then into a gabbro. These different rocks seem to be part of one intrusive mass. The same phenomenon is found in the Garabal Hill district.[10] The same intrusion is at one part ultra-basic, at another highly siliceous.

Closely connected with this is the fact that, in many districts where a number of intrusions or eruptions have occurred, the types of rock formed constitute a continuous series. For example, in the Christiania district the eruptions begin with dolerite. Then comes an intermediate rock with a high soda

Digitized by Google

percentage—a nepheline syenite. The silica percentage again increases, and a true granite occurs. Finally, a dolerite closes the series.

In his recent memoir on the igneous rocks of Skye Mr. Harker notes the same succession of rock types from basic to acid, with a reverse succession from acid to basic, in the dykes of that region. The separation of the magma into a basic and an acid portion he believes took place before intrusion.

From the relations of the rocks, it seems certain that they have all crystallised from the same molten magma. The magma at one time was probably quite homogeneous, so that some forces must have been at work causing the molten mass to separate into different petrological types. The process is generally called magmatic differentiation, and various hypotheses have been put forward to explain it. Most of them fall under three heads—(1) Differentiation by crystallisation, (2) differentiation by diffusion, (3) differentiation by liquation.

Differentiation by Crystallisation.—We have seen that the more basic minerals with a high specific gravity crystallise out first. If these, by the action of gravity, accumulated in the lower part of the magma, obviously a separation of the magma into a more acid and a more basic portion would have been effected. Becker's view is that crystallisation takes place on the enclosing walls of the reservoir. Convection currents are set up, which furnish new supplies of material to be crystallised. In this way a more basic rock is formed at the boundaries and a more acid at the centre of the intrusion. Brögger believes this hypothesis is valid.

Differentiation by Diffusion.—Soret's principle states that the part of a solution nearest its saturation point moves towards the cooling surface. As the more basic minerals crystallise first, just before crystallisation the basic-saturated part of the solution would move towards the cooling surface, and so alter the uniform character of the magma. Iddings, in America, emphasises this view. Teall thinks, though a true cause, it is not sufficient.

Differentiation by Liquation.—A plausible and most suggestive explanation of magmatic differentiation is that of liquation. We know of cases where two solutions mix freely with each

Digitized by Google

other at certain temperatures, forming a perfectly homogeneous liquid. On lowering the temperature, however, the liquid separates into two different solutions that do not mix. If molten silicates act in the same way, we see that at a certain stage in the cooling the originally homogeneous magma will separate into two or more non-miscible magmas, which will finally consolidate as quite different types of rock. Weinschenk, of Munich, inclines to this explanation.

Whatever the mechanism of the process may be, it seems to be a true evolution of rock species. It corresponds in every detail with Herbert Spencer's famous definition of evolution—"a continuous change from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity by successive differentiations and integrations."

After crystallisation has taken place, the reverse process, termed resorption, has sometimes occurred. Certain minerals, particularly hornblende and biotite, show corroded edges, or even complete replacement by magnetite. This has probably occurred when the lava at an eruption changed its intra-telluric environment for surface conditions. With most bodies an increase of pressure raises the melting point. The decrease of pressure at the surface may therefore lower the melting point of a crystal below the temperature of the surrounding molten material, which will therefore cause a refusion of the crystal round the edges or a complete decomposition of the mineral.

The raising of the melting point by pressure is of great interest in speculations on the state of the earth's interior. At only a moderate depth below the surface, rocks are at a temperature far above their melting points at atmospheric pressure. It is claimed, however, by almost all physicists that the increased pressure raises the melting point sufficiently to keep the rocks in a solid state. They are in a state of potential liquidity, and a lowering of the pressure would immediately bring about their fusion.

But this applies only to bodies that contract on solidifying. Several metals, notably iron, and perhaps some silicates, expand on changing into the solid state, and with these bodies the opposite result obtains. Increase of pressure tends to keep them liquid. Again, it is well known that for every gas there

Digitized by Google

is a "critical point," a temperature above which no increase of pressure, however great, can liquefy the gas. Similarly, it is not improbable that a liquid should have a critical point, above which it cannot be solidified by any pressure.

A most interesting but intricate problem in crystallisation is the explanation of the crystallisation of the metamorphic rocks. The details of contact metamorphism are fairly well known. There must be a considerable molecular mobility for the minerals to show the outlines they do, but there is no sign of any true fusion in the rocks that show the greatest mineral changes. Recent experiments on the crystallisation of metals, however, show that crystallisation may take place even after the final solidification of the metal.

On the question of regional or dynamic metamorphism, however, opinion is still sharply divided. The subject is far too involved to be entered into in detail, but there seems to be a tendency to think that its recrystallisation effects have been exaggerated. Many of the archæan gneisses are now believed to be true, banded, igneous rocks, and the detailed study of the Highland schists has shown that contact metamorphism is responsible for the crystalline nature of many of the rocks. However, the heat mechanically generated by the rock-crushing seems a potent aid to crystallisation.

REFERENCES.

1. E. Weinschenk, "Grundzüge der Gesteinskünde," 1902, vol. i., p. 40.
2. "Memoire sur les Roches dites Plutoniennes de la Belgique," Acad. Roy. Belg., 1876.
3. Michel Lévy, "Roches Éruptives," p. 6. R. H. Rastall, "Buttermere and Ennerdale Granophyre," *Quart. Jour. Geol. Soc.*, 1906, p. 260.
4. Drs. Peach and Horne, "Silurian Rocks of Britain," vol. 1., p. 483.
5. Daubrée, "Geologie Experimentale," p. 28.
6. Op. cit., p. 38.
7. See Fouqué and Lévy, "Synthèse des Minéraux et des Roches," or Dana, "System of Mineralogy."
8. Williams, "Origin of Maryland Pegmatites," U.S. Geol. Survey Report, 1893-94.
9. A. Harker, "Tertiary Igneous Rocks of Skye," 1904.
10. Teall and Dakyns, *Quart. Jour. Geol. Soc.*, 1892, p. 104.

Digitized by Google

No. XL.—Notes on the Discovery of an Outlier of the Loch Tay Limestone on Beinn Bhreac, Loch Tay, Perthshire. By Peter Macnair.

[Read 12th January, 1905.]

The importance of the Loch Tay Limestone as a datum line for determining the position of the upper and lower schists in the crystalline rocks of the Highlands has long been recognised. Within a comparatively recent period another important schist zone, known as the "green beds," has been differentiated out from the Highland rocks. By the identification of these well-marked schist zones it has been made possible to follow, with more or less success, the complicated foldings into which the rocks of the Highlands have been thrown.

It is not my intention in these notes to enter into anything like a detailed description of the structure of the Central Highlands—the broad features of which I have described elsewhere—but let me just briefly state that the crystalline schists of the Highlands have been plicated into a series of isoclinal folds which appear to be arranged along great axes of folding.

In the neighbourhood of Killin the Loch Tay Limestone can be well seen in the bed of the Dochart, where it has an apparent dip towards the north-west. From the bed of the Dochart the limestone appears to ascend the side of Sron Clachan to near the precipice known as Cnoc-a-Mhanaich, where a fine section may be seen in association with the epidiorite. Traced eastwards round Sron Clachan, the limestone evidently covers the whole of the ground between the main street of the village and the 1000-feet contour line, and may be seen at various points, as above the manse and at Maragowan. From this point the limestone stretches along the side of Loch Tay, forming the base of Craig-na-Calleich, and evidently dipping at a considerable angle below that mountain. Numerous fine sections may be observed along the road which leads to Kenmore—for instance, upon the road about half a mile beyond the inn, and immediately on this side of the keeper's house, probably the Drum-na-larig of the inch Ordnance Survey map. At this

Digitized by Google

point the main body of the limestone is seen to be dipping towards the north-west at an angle of 45°, and an examination of it shows that it is banded with layers of more micaceous material alternating with bands of pure limestone. The rock has been thrown into a number of folds, which are very clearly shown owing to the banded structure. The longer axes of the folds are seen to distinctly hade with the main body of the limestone, namely, towards the north-west, the overfolding being consequently towards the south-east, while the under limbs are those which are most thinned. From this it would appear that the direction from which the thrust has been applied has been the north-west, and that it has been transmitted towards the south-east, and we find that, as a rule, this seems to be the general law of folding in this part of the Highlands. Associated with the Loch Tay Limestone there occurs a remarkable group of altered basic rocks—which have already been described by the author in a paper read before this Society; they are known to accompany the Loch Tay Limestone from shore to shore across the whole of the Southern Highlands. In the neighbourhood of Killin they may invariably be seen accompanying the Loch Tay Limestone, being of the character of epidiorites and hornblende schists. In appearance these rocks are generally of a dark grey or almost black colour, and being generally harder than the limestone with which they are associated, they are often seen to present bolder outcrops than the latter rock. So far as I have observed, they never show any evidence of a scoriaceous or vesicular structure, and at certain places, as near Finlarig, they give evidence of contact metamorphism. At places I also think they appear to transgress the clastic schists with which they are associated, but upon this point I would not like to speak with any degree of assurance. The whole aspect of these rocks has led me to the conclusion that they are of the nature of sills of basic igneous rock, which have been intruded along lines of junction between the clastic schists. So completely has the subsequent metamorphism rolled out and welded these rocks into one another that it becomes exceedingly difficult, if not impossible, to say what their original relationships might have been.

I now turn to a brief description of the geological position and geographical extent of the outcrops of the Loch Tay Lime-

Digitized by Google

stone in the neighbourhood of Loch Tay. In the first place, and as I have already pointed out, the limestone may be seen in the bed of the Dochart, near Acharn; it has an apparent dip towards the north-west at an angle of about 45°, and seems to underlie the schists that cap the summit of Sron Clachan, and which belong to the garnetiferous schist series, from whence the outcrop can be traced eastwards, round the foot of Sron Clachan, crossing the mouth of Glen Lochay, and running along the north side of Loch Tay, where it also appears to underlie the garnetiferous schists dipping north-west at an angle of about 45°. Returning to the exposure in Glen Dochart, the limestones are well exposed in the bed of the stream which, flowing from Lochan-Larig-Eala, joins the river Dochart near Easter Lix. Ascending the stream, a somewhat extensive outcrop of the limestone is passed over, still apparently dipping north-west, but getting gradually flatter as we ascend the stream; a similar section is seen in the Ardychle Burn, between the village and the ford. Near the village the dip is distinctly north-west, but in ascending the burn the dip becomes flatter and flatter, till it eventually rolls over and appears to dip south-east and under Creag MacRanaich. At Glen Ogle head an exposure of the limestone is seen by the roadway near the station; here the limestone has been considerably folded, and appears to dip towards the south-east; outcrops of the epidiorite are also seen in the neighbourhood. From the head of Glen Ogle the limestone may be traced more or less continuously along the northern side of Beinn Leathan, and, though it is much covered with drift, excellent sections of it may be seen in the beds of the Alt-nan-Sliab and the Alt-ant Socaich, at a point a little higher up the hillside than where they unite. From this point the limestone can be traced along the hillside to the north of Creag Charb, where it is thrown out by the powerful fault which runs across Loch Tay to the east of Ardeonaig. On descending Glen Ogle the limestone which was seen at its head disappears for the space of about two miles, but again appears about halfway down the Glen, in the bed of the stream, accompanied by beds of epidiorite, the dip of the schists being now almost flat, or slightly towards the north-west. From the foot of Glen Ogle the limestone may be traced in a large horse-shoe curve up Gleann Ceann Droma; then, bending round the foot of

Digitized by Google

Meall-ant-Seallaidh, its beds sweep round the Kirkton Glen, and back into the main valley of the Dochart. At the head of Loch Earn the limestones, as I have already noted, seem to undulate gently towards the south-east, plunging below the garnetiferous schists of Meall-nan-Uamh to the east of Lochearnhead Station, and abutting against the Glen Ample fault. From the northern shores of Loch Earn, near Dalveich, the limestone may be traced up Glen Beich for nearly three miles upon the west side of this great fault.

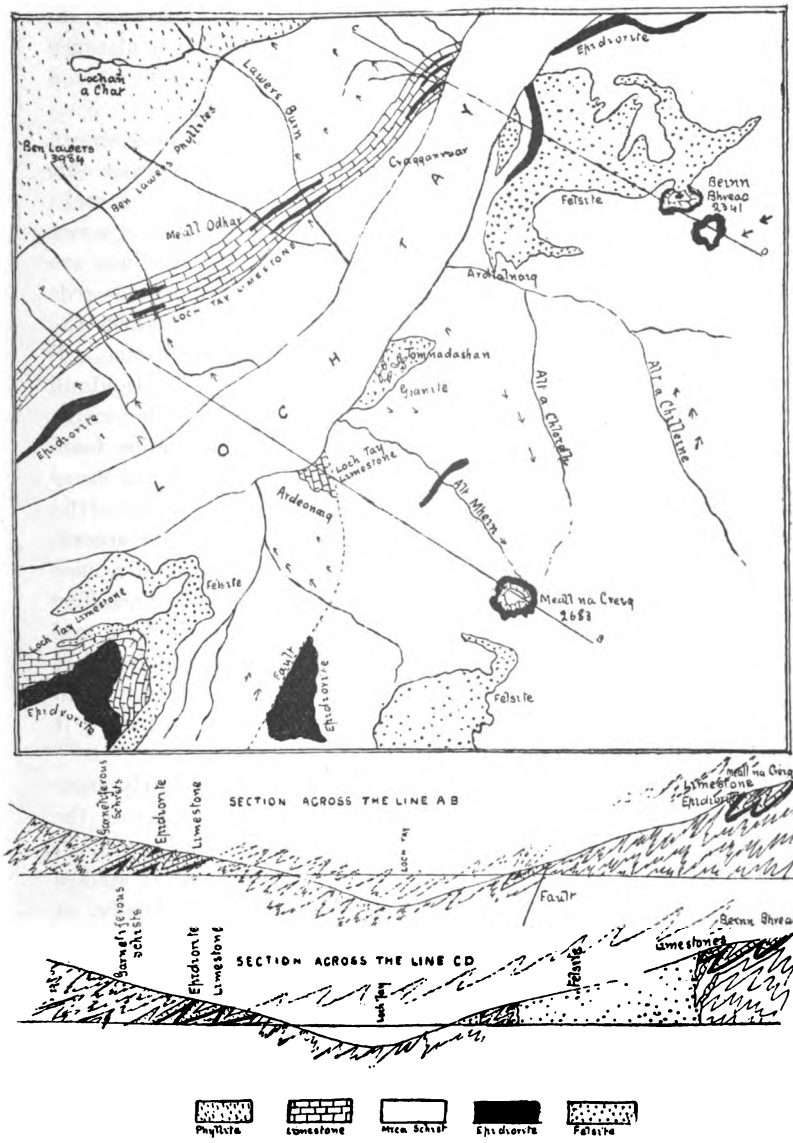
The description which I have given of the Loch Tay Limestone refers to those outcrops which lie to the west of the great north-east and south-west fault that springs from the boundary fault, near Loch Vennacher, and trends north-eastwards by Loch Lubnaig, Glen Ample, Loch Earn, Glen Beich, Loch Tay, Loch Tummel, Blair Atholl, and the valley of the Tilt. The general effect of this fault and similar parallel ones has been to destroy the continuity of the great axial lines of folding in the schists, and thereby tends to obscure the geological structure of the ground. In the Loch Tay fault the downthrow side is towards the west, and, in the neighbourhood of Loch Tay, amounts to over 2000 feet. It is interesting to note that the existence of this fault was first recognised by a distinguished West of Scotland geologist, Dr. Bryce, and I quote from his paper as follows:—"In Edinample Glen, under the falls, there is a great fracture in the strata and anticlinal axis in the slate. The river under the falls, which are the finest about Loch Earn, is, in fact, along the line of this fault or great rend in the beds, which ascends towards the mountain on the south, and seems indicated by a slip in the hillside." At Ardeonaig this great fault enters the east side of Loch Tay, and passes across the loch to Fernan on the west. At both these localities the Loch Tay Limestone appears abutting against the fault, and dipping towards the north-west in the manner already described, forming, as I have already pointed out, part of the southern limb of the fan-shaped structure of Ben Lawers. At both these localities the limestone is upon the level of the loch. On the east side of the great fault the limestone has entirely disappeared, and the schists appear to belong to a horizon lower than the Loch Tay Limestone; but, as no well-marked zones appear in them, it is difficult to say whether they belong in part to the "green

Digitized by Google

beds" and Ben Ledi grits in a higher stage of metamorphism or whether they represent a group of strata lying between the Loch Tay Limestone on the one hand and the "green beds" on the other. On the east side of the fault a single outlier of the Loch Tay Limestone has been recognised as occurring on the summit of Meall-na-Creig, a mountain situated about two miles to the south-east of Ardeonaig, and which has an altitude of 2683 feet above sea-level. The existence of this outlier has been known for a considerable time, as the late Marquis of Breadalbane wrought certain veins of galena which occur in the limestone on the summit of the mountain. There cannot be any doubt that it is the Loch Tay Limestone, as it presents exactly the same mineralogical character as that seen at Maragbeg, near Ardeonaig; further, it is accompanied by the epidiorite in a similar manner to that seen in the main outcrop on the north side of Loch Tay. This outlier, then, clearly points to the fault having a downthrow of over 2000 feet to the west, and is of extreme importance both from a structural and stratigraphical standpoint.

Now, so far as I am aware, this is the only outlier of the Loch Tay Limestone which has been recognised to the east of the great fault and upon the south side of the Tay Valley, and I cannot find any other indicated on sheet 47 of the Geological Survey, so that I can assure you that I was greatly surprised when, during the Christmas holidays, while staying at Milton Ardtalnaig with my friend Mr. MacDougall, he informed me that the Loch Tay Limestone had been long and somewhat extensively quarried on Beinn Bhreac, a mountain situated about two miles to the east of Ardtalnaig; consequently, along with Mr. Duncan MacDougall, I determined to visit the locality and see for myself. This we did on the second day of the year, and found that Mr. MacDougall was perfectly correct, and that near the summit of Beinn Bhreac an outlier of the Loch Tay Limestone had been worked, and also that the limestone is accompanied by the usual bed of epidiorite. Neither of these appears in the Geological Survey map, and their existence seems to have been overlooked. The outlier appears to be exactly a counterpart of that seen on Meall-na-Creig, and it is interesting to note that the altitude of the two mountains and their geographical relationships to the normal outcrop of the Loch Tay

Digitized by Google



Sketch Map of the Loch Tay District to illustrate the occurrence of the Outlier of the Loch Tay Limestone on Meall Bhreac and Meall-na-Creig.

Digitized by Google

Limestone are much the same, namely, they appear at an elevation of about 2000 feet above sea-level, and at a distance of about two miles from where the great fault cuts the outcrop of the limestone.

In my paper on the Building of the Grampians* I have shown that there passes down the centre of the Highlands a great axis of folding, having a fan-shaped structure from which the rocks are thrown off towards the north-east and south-west in a series of isoclinal folds. Near the apex of the fan the isoclines are vertical. On each side the axes of the folds dip inwards towards the north-east and south-west respectively. Traced towards the south-east, the axes of the folds become flatter and flatter, till they become almost horizontal. On approaching the Highland frontier they again begin to rise, till they dip towards the north-east at a high angle. In following certain lines of section from the apex of the fan towards the south-east, lower and still lower beds rise to the surface. On the apex of the fan we have the Upper Argillaceous Zone, which is represented in the accompanying map by the Ben Lawers Phyllites; further south comes the outcrop of the Garnetiferous Schist Zone, then the Loch Tay Limestone Zone, followed by the Lower Arenaceous Zone and the Lower Argillaceous Zone seen along the Highland frontier. This is undoubtedly the most prominent structural feature in the schists of this part of the Highlands, and I have named it the Ben Lawers fächer or fan-shaped structure.

The exact position of this axis of folding can be fairly accurately determined in tracing it from west to east across the Central Highlands. It is seen, first of all, on the shores of Loch Craignish, in the Sound of Jura, from which point it strikes north-eastwards by Kilmelfort, Kilchrennan, and Dalmally, at the head of Loch Awe; in this area the centre of the fan-shaped structure or fächer is occupied by the members of the Upper Arenaceous Zone. From Dalmally the axis can be followed up Glen Lochay, by Ben Lui, and from thence along the ridge that separates Glen Dochart and Glen Lochay, through Meall Chuirn, Meall-na-Saone, and Craig Mhor, where it enters Glen Lochay near the Falls of Lochay. From this point it stretches along

* *Proceedings* of the Royal Philosophical Society of Glasgow, vol. xxxv., p. 147.

Digitized by Google

the crest of the ridge that separates the valley of Loch Tay and Glen Lyon, passing through Coir Fionn Lairge, Meall-nan-Tarmachan, Ben Lawers, Meall Garbh, Meall Gruaidh; entering Loch Tay near Sron Fernan, it abuts against the Loch Tay Fault at Wester Achtar. On the east side of Loch Tay Fault the axis reappears at White Bridge, and now follows the ridge that divides the valley of the Tay and the Tummell, passing through Meall Fead and Cammoch Hill, and entering the valley of the Garry about three miles to the north of Pitlochry.

As has already been pointed out, the downthrow of the Loch Tay Fault is to the west, and it shifts the outcrops of the schist zones for a distance of about four miles to the south-west. Similar faults having like effects, and running roughly parallel with the Loch Tay Fault, have been traced further to the west. These cross faults or parallel wrenches run into the great boundary fault, and they appear to have been produced during the period of folding indicated by the great axial lines which have been described. As these axial lines of folding are traced towards the west they show evidence of having been driven more closely together along these parallel wrenches, this being accompanied by a greater piling up of the strata and a more intense metamorphism.

Digitized by Google

No. XLI.—The Parallel Roads of Lochaber with relation to an Ice Cap. By Colin Livingston.

[Read 13th April, 1905.]

Of the various theories which have been advanced as to the formation of these "roads," that which attributes them to the existence of large lakes caused by ice barriers during the Glacial Period in Glen More has found most acceptance.

In a paper in the *Journal* of the London Geological Society, 21st January, 1863, Mr. T. F. Jamieson, of Ellon, Aberdeenshire, endeavoured to account for the existence of such barriers by supposing a flow of ice from the several glens which meet in Glen More, between the present Glen Arkaig and Fort-William. The principal of these is Glen Spean, into the mouth of which, as it merges into Glen More, he supposed there was a large flow of ice from Coire 'n Eoin. Another barrier was provided in Upper Glen Spean from Glen Treig.

Without further reference to the other writers who supported this view, or to those who advanced other theories, I shall here mention only Mr. William Jolly, a member of this Society, among the former, and Mr. David Milne Hume among the latter. Mr. Hume maintained that the barrier, instead of being ice, consisted of detritus.

Mr. Jamieson, some twenty years after his first paper, published in the *Quarterly Journal* of the Geological Society, 1892, a paper in which he abandoned the separate glacier theory and gave reasons for the existence of a general ice cap, within which he supposed the lakes to have been formed.

Accepting the idea of a general ice cap covering this part of Scotland from sea to sea, I question the formation within this ice cap of lakes of large size in the higher glens while the lower valleys were blocked with ice.

The Märjelen Sea is usually brought forward as evidence in support of such a theory. But, if it proves anything at all, it proves that the supposed Lochaber Lakes were an impossibility.

Digitized by Google

The Märjelen Sea is really a very small sheet of water whose surface, according to the accounts, never exceeds a square mile with varying depths, formed by the blocking of a small lateral valley, below the snow line, by a protruding glacier with a large ice field behind to maintain the barrier. At intervals of from three to five years it bursts through this barrier with much turmoil and breaking up of ice.

Some Norwegian lakelets are also occasionally referred to in the same connection, but these appear to burst through their barriers annually with great devastation.

If there were such Lochaber Lakes as is supposed, they were formed within the snow line, and were of such a size that the Märjelen Sea would find room in several of the lateral valleys which they occupied. Its loss among them would be unobserved. If its discharge is accompanied with rupture of ice and tearing up of earthy material, the discharge of the Lochaber Lakes would have left marks which no length of time would efface. The supposed "debacle" at Roughburn is a very recent production and of very small extent.

I propose in this paper (1) to examine the evidence in favour of the lake theory of the formation of the parallels; (2) the evidence against that theory; (3) to account for the parallels otherwise than by the existence of lakes.

I. The Evidence in Favour of the Lake Theory.

Once the lake idea has been suggested nothing is easier at first sight than its acceptance as a sufficient explanation of the existence of the parallels. There they are, one below the other, along the hillsides, and practically horizontal as the surface of a subsiding lake would be at the various stages of subsidence, and they bear a considerable resemblance to the beaches of existing lakes. The most casual visitor to the glens has only to go up Glen Roy, some four miles from Roy Bridge, to satisfy himself that here at some past time there has been a lake, and that these are its margins. He may hesitate to accept the statement that at the mouths of the glens there was an ice barrier while the heads of these glens were clear of snow and ice. That is so very contrary to the experience of the present day that its acceptance as a fact requires some

Digitized by Google

consideration. But, that difficulty overcome, when he is told, or finds in his map, that the successive terraces are on a level, or nearly so, with the cols at the head of the respective glens, his assurance is complete. He hastens home and writes a paper embodying his own observations and the information which he has received or gathered. He has, indeed, all the evidence there is in favour of the lake theory of the formation of the Parallel Roads.

II. The Counter Evidence.

Since first I became acquainted with the district I have had some difficulty in accepting the lake theory, and frequently tried to substitute for it something even less satisfactory, as I now am assured.

The observations of many years—now nearly forty—have added from time to time to my knowledge of facts for which the existence of lakes cannot account. There was always, what I am inclined to hold as an insuperable difficulty, the existence of lakes at a high level with ice at what is now the sea level, or nearly so, and with only a fragile barrier of ice retaining so large a body of water. There was also present to my eyes, when I moved a few miles from home towards what was the bed of the supposed lake in Glen Spean, the moraines that must have been formed by ice moving out of Glen Spean—supposed to be a lake—after the barrier which caused that lake had been removed. I could not imagine a Glen Spean Glacier after there had been a Glen Spean Lake.

The moraines to which I refer cross the public road—or the railway—between Fort-William and Spean Bridge. The lowest or farthest forward of them is met with at Auchandaul Gate. It may be traced almost continuously from near the end of the parallel on the north of the Spean, down to the river, up the south side—where it forms a very conspicuous object—across the Auchandaul Valley, and onwards to near the base of the Ben Nevis range of mountains. Near Auchandaul Gate it forms what is known as Tom-na-Brataich—the Banner Mound—much of which has been removed to form railway ballast.

The total length of the moraine line is about 6 miles, though not quite continuous. In parts it rises to a height of 20 to

Digitized by Google

30 feet with a base of as many yards. Sometimes, in the face of a hill which the ice was ascending, the forward part merged into the general surface, and only the side towards the ice was left steep. Tom-na-Brataich, from 80 to 90 feet high, is composed for the most part of fine sand.

Three other moraine lines lie within this outer line towards Spean Bridge. They contract both in length and height as the glacier which produced them may be supposed to have diminished in magnitude. All curve towards Glen Spean and have their steep sides facing in that direction, showing that the ice which formed them issued from that glen. A mound in one of the lines, cut into for road-repairing material, consists in large part of small angular and sub-angular chips of stone.

It is evident that these lines could not have been formed previous to the formation of the barrier which is supposed to have occupied this position. Nor would they have been formed subsequent to its removal had Glen Spean been the bed of a lake. They are the products of the ice which must have continued to flow from that glen till the very close of the Glacial Period.

The Evidence Furnished by the Roads.

The doubts caused by the existence of these lines led to a questioning of the "roads" themselves. Though to the eye they appear quite level, the Ordnance measurements show considerable differences of level, varying from 8 to 12 feet or more within short distances. These differences in level led Professor Prestwich to the conclusion that the "roads" are not lake margins. But there are proofs that to me appear to point much more certainly to the same conclusion. Any one who has walked along the margin of a Highland lake must have observed its shingly character. No shingle is to be found along the "roads," nor do they show the exposed blocks of stone that are common along lake margins. There are none of these capes and bays, or of the naked rocks or steep banks which form a lake shore, nor is there any of the undercut which is inseparable from the margin of any storm-swept watery surface.

Digitized by Google

Then, it will be observed wherever a stream falls into a lake there is a sort of deltoid accumulation at its mouth. There are no such collections of mud and sand where the parallels are cut by the hundreds of streams by which they are crossed. They come with amazing evenness to the brink of the stream on both sides and show no deltoid accumulations. There are, in the bottom of the valley in Glen Roy, many large accumulations of detritus, but they are not deltoid. They were formed while the glen was in its present condition without ice or lake, and are the product of streams which still continue to flow.

Near the head of Glen Roy, not far from the col towards Lochan Spey, there is a pretty extensive piece of ground at what is known as Lùb Chonnail. On the left bank of the small stream—tributary of the Roy—there is the farthest piece of "road" in this direction. On the opposite side the plain slopes gradually towards the hillside. On this plain there is a lonely shepherd's house, 1070 feet above sea-level. Had there been a lake, as supposed, the height of its surface above the spot on which the house stands would be 90 feet. To this point the south-west wind would sweep through the whole length of Glen Roy and roll before it waves that would compare with Atlantic billows. They would throw up on the lake margin vast masses of shingle, which both border and bottom would supply in abundance. No heaps of shingle are to be found, and there is no undercutting of the banks where the margin of the lake—if lake there were—would have touched the steeper banks. There is on one bank about half a mile of "road" formed evidently without the action of any far-rolling waves.

The absence of "roads" for so many miles in the glens, where in parts they are to be found, is no less evidence against the existence of the supposed lakes than is the presence of the "roads" evidence in its favour.

On the left side of Glen Gloy there are few traces of "roads." For miles on the left of Glen Spean no trace of its "road" is to be found. For some 10 or 12 miles at the head of the glen, or 20 miles including both sides of Loch Laggan, there is no "road," and in various other parts the "roads" are conspicuously absent. If there were lakes there would be

Digitized by Google

continuous lake margins, or almost continuous. In parts they might have been obliterated, but obliteration would not extend for a score of miles, and the causes would be evident.

Minor Lines.

The main lines are on a level, or nearly so, with four cols at the head of the same number of glens. But there are several minor lines that have no connection with any col. The greater development of the principal lines will have to be accounted for. The existence of the others, however, prove that a col was not essential to the formation of a line quite similar to those which have a col at one of their extremities.

Professor Prestwich accounts for the main lines by a detrital slide down the hillsides to the lake levels. Of the minor lines, like most other writers on the subject, he takes no notice. It is doubtful, in fact, whether he can have seen them at all. His time for observation, he explains, was somewhat limited.

A fuller acquaintance with the facts would doubtless compel him to abandon his slide theory. He would find parts of the "roads" very well marked where material for such a slide as would be necessary to form them could not be produced; and simultaneous slides extending over many miles are unlikely occurrences. Their being brought to a stop at the same level by the water of a lake is still more unlikely, but ice would check their downward progress.

Of the minor lines there are four in Glen Gloy: two towards the head of the glen higher than the main line, and other two towards the lower end of the glen below the main line. The lower of these I made by aneroid to be 722 feet above sea-level; the upper about 60 feet higher. The elevation of the main line is given in the Ordnance plan as varying from 1156 to 1175 feet above Ordnance datum, and the others are respectively about 30 and 60 feet higher.

Sir Henry James, in his "Parallel Roads of Lochaber," in "Sketch No. 2," shows the two lines near the head of the glen and says of them, "The two upper tracks, though well marked to the eye from this point of view and parallel to the lower one, show nothing when you reach the ground to indicate 'roads.'" With the concluding part of this remark

Digitized by Google

I cannot quite agree. The indications, as compared with the broad main line, are certainly faint, but they are quite distinguishable. The quantity of material forming the lines is small, but the character of the herbage is well marked, as it is generally on the "roads." I have followed each of them more than once for some distance. The higher one as the distance increases from its upper termination loses its horizontality. It rises slowly, and in one part, for about 100 yards, forms a distinct moraine. It can have been no lake margin.

These five lines—including the main "road"—are on the proper right of the river—the west side of the glen. On the other side the main "road" appears only in parts; but at the mouth of Glen Fintaig, on the right of that glen, two lines are for a short distance well marked.

In Glen Roy on the two sides of Allt nan Eun, on the east side of Beinn Iaruinn, as shown on the Ordnance 6-inch plan, there are four "roads" instead of the usual three; and in "Glen Glaster," on the shoulder of Meall Dubh, there is part of a fourth "road" shown. Their existence has been verified.

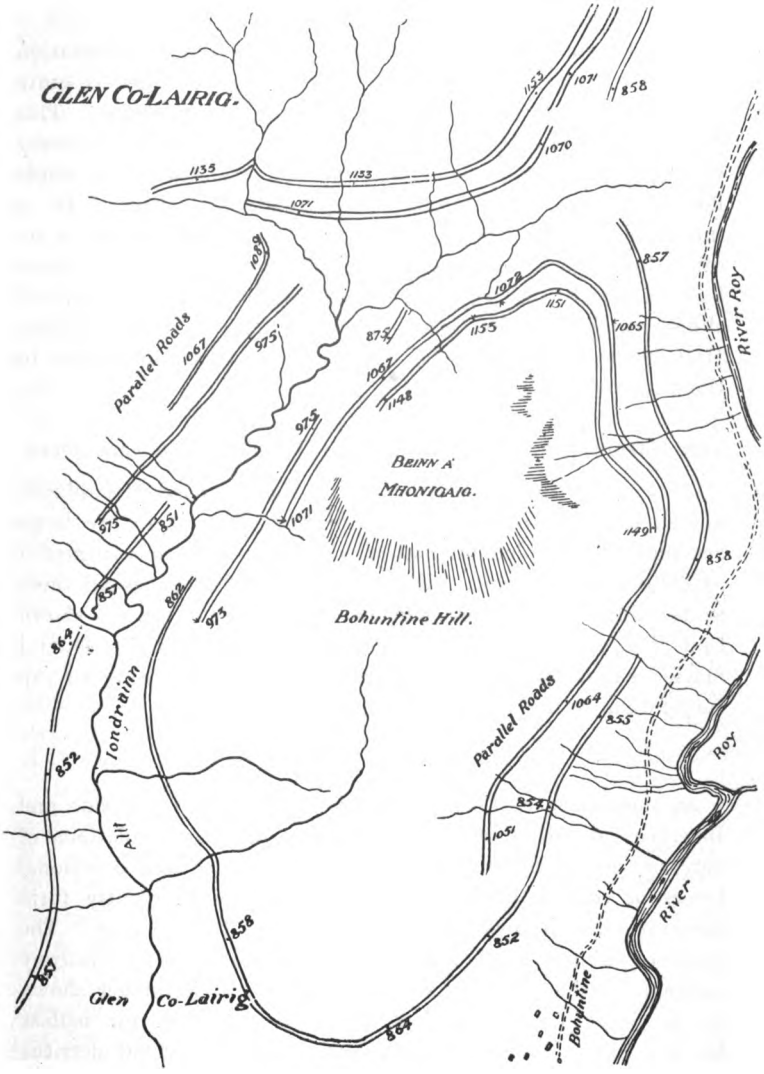
In Glen Spean, also, at the mouth of Loch Treig there are in parts two lines in place of the single line on the level of the "Mackoul" col.

Glen Co-Lairig.

But by far the most perplexing part to the lake theorist is Glen Co-Lairig. This glen is on the west side of Bohuntine Hill, at the head of Allt Iondruinn, which is crossed on the way up Glen Roy about a mile from Roy Bridge. Upon the right bank of this stream there are shown on the Ordnance 6-inch plan no fewer than five "roads," at elevations of 1135, 1071, 1067, 975, and 864 feet respectively. On the Bohuntine hillside there are four at 1150, 1067, 975, and 862 feet above Ordnance datum.

The 1071 and 1067 feet lines on the right correspond nearly with No. 2 Glen Roy line; on the left the 1150 and 1067 feet lines correspond with Nos. 1 and 2 in Glen Roy. The 864 feet line on the right and the 862 feet on the left correspond with the lowest line in Glen Roy and with the Glen Spean line

Digitized by Google



Digitized by Google

855 feet line. The others have no corresponding lines. It will be observed also that the lines on the opposite sides of this short glen do not quite correspond in level.

The existence of so many lines at such a variety of elevation within so limited an area—under one square mile—is quite inconsistent with the idea of their being lake margins. This glen would have been only one bay of a large lake, and whatever change of level occurred here must have extended to the whole lake occupying the Spean Valley and Glen Roy. It is impossible, if this had been the case, that there could be no other indications of the numerous changes in level that must have occurred. There is very little room also for the detrital slides required by Professor Prestwich; nor would Mr. Milne Hume's detrital barrier be effective here any more than in the wider valleys.

The Detrital Accumulations of a Quasi-Deltoid Character.

At the mouth of Loch Treig, at the so-called Roughburn, and in Glen Turret at the head of Glen Roy, there are large accumulations of detrital matter which are sometimes regarded as deltoid in character. Professor Prestwich regards all these as terminal moraines of glaciers. I believe it can be shown that all are owing to the action of water, but that the detrital matter was deposited at the margin of the decomposing ice cap rather than in a lake.

The Loch Treig Accumulations.

At the mouth of Loch Treig, at Fersit on the one side and Inverlair on the other, there are very large accumulations of detritus, consisting in great part of fine sand with occasional layers of coarser material. The two masses evidently form parts of a larger mass cut through by the River Treig. The character of the whole has been well disclosed by the railway cuttings on the right bank of the Treig, and is further shown in the large face exposed in procuring material for ballast for the line. It is quite different from the glacial detritus so abundant on the adjoining hillsides and on the plain at a lower level. This detritus would be utterly unsuitable for the purposes for which the material at Fersit is used; and there

Digitized by Google

is quite enough exposed to show that the material on the Inverlair side of the Treig is of the same character.

Material of this kind, if deposited in the water of a lake, would be continuous except in so far as affected by currents or as subsequently washed away by streams. The general appearance of these accumulations, looked at from a distance, is that of a level plateau. In one or two places this has been cut through by streams, but from a distance the whole appears a level surface. A closer examination, however, shows that, on the Fersit side especially, the forward part of the plateau is honeycombed, as it were, by numerous small hollows.

These hollows vary in size from 100 square yards to twice that area. Their banks are from 20 to 50 feet high, and slope at about the angle of the rest of the materials of which they are composed. A number of the hollows contain water with no stream entering or leaving them. Others are dry, and one or two have been cut through by a mountain stream on its course to the Treig.

The divisions between several of the hollows are quite narrow, sloping down on both sides like the roof of a house. The narrow ridges generally have formed sheep tracks, but the sheep are now removed.

These hollows were evidently formed on the margin of the ice field occupying the main valley. They could not possibly have been formed under water. The ice was cut up by surface streams, which divided it into patches of various sizes. Into the channels thus formed in the decomposing ice sand and gravel were swept from the surface, leaving the whole comparatively level. As deposited, the sand at the bottom of the dividing channel would be narrower than at the surface. But as the sustaining ice wasted away the overlapping edges of the sand would sink down on both sides, leaving a narrow ridge in the middle.

In many cases the ice patches were probably altogether covered by the sand, which would preserve the underlying ice for years. As the ice wasted slowly away the sand would sink, leaving a hollow. This was what in all probability happened in the case of the deeper hollows, where water now remains.

Digitized by Google

On the Inverlair side the hollows, with two exceptions, are dry, or nearly so. One is occupied by the Dubh Lochan, which, however, has a small stream entering and leaving it. Near its lower end, and separated from it by the Fersit cart road, is a small pool without any stream.

On the moor, between the foot of Loch Treig and the Spean, there are several pools of like kind. Some have streams and others neither inflow nor outflow. Two small pools on the right bank of the Spean are of the latter character. One of them occurs among the "Roughburn" detritus, and there are various other similar pools.

The Roughburn Accumulation.

The name "Roughburn," which seems to give countenance to the idea that here there may have been the bursting of a barrier, is quite modern, and was given to the shepherd's house when built. Allt a Chaoruinn—Rowan Burn, the original name of the stream—here joins the Spean. The public road crosses the Allt at an acute angle, and, of course, the bridge was built at right angles with the road. This had the effect of directing the current of the burn against the right bank, which was consequently in part washed away, leaving exposed a quantity of stones, some of them of considerable size.

This has been called a "debacle," and is the only spot within the area of the parallels to which the term has been applied. It is, in reality, evidence of the labour of human hands rather than of the breaking down of any ice barrier or of a great flow of water at any time from the Glen Glaster col. No evidence of such a flow exists.

The existing stream from the col is small and smooth flowing. It is known as a "Feith," which is the name usually given to almost stagnant water or a marsh.

But when the ice on the adjoining bens was being decomposed there would be in this direction a great rush of water, though not from Glen Roy. And here there is a large collection of water-borne material, of generally a rougher character than that at the mouth of Loch Treig. The nearness of the mountain sources made the water carriage shorter than on the

Digitized by Google

opposite side, and the wearing down of the material rolled along by it was less complete. A pond—as already mentioned—indicates that the material was deposited among ice. The River Spean cuts off this detrital accumulation from the opposite moor.

The Glen Turret Mounds.

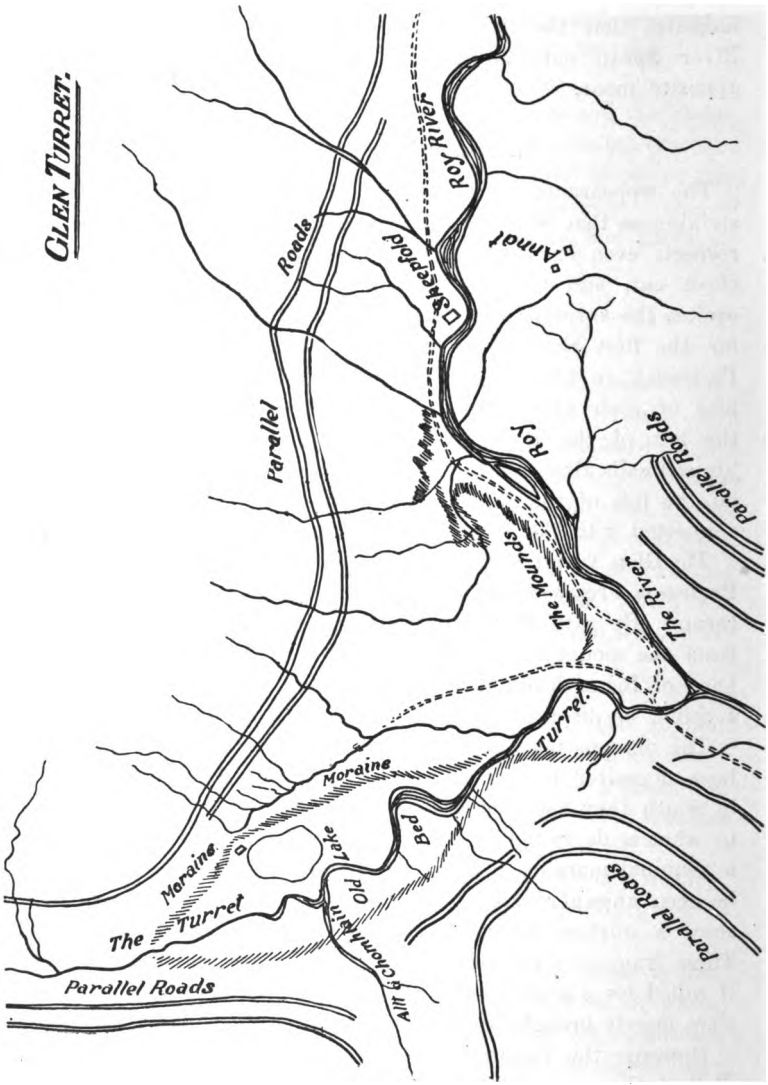
The appearance of the Glen Turret mounds is quite as striking as that of the Loch Treig accumulations, and in some respects even more so. The long line of steep faces, almost clean cut, and towards the lower end some 90 feet high, excites the surprise and wonder of any one on beholding them for the first time. The view of them given by Professor Prestwich in his paper on the Parallel Roads gives a good idea of their appearance. A mound is shown, however, on the left of the Roy which does not exist. The Professor himself calls attention to the smallness of the detrital collections on the left of the Roy as compared with those on the right connected with the Turret, a much smaller stream.

The Glen Turret mounds are frequently referred to as deltoid. Professor Prestwich objects to the application to them of this term. He says they are the terminal moraine of a glacier from the mountains at the head of the Turret and from the back of Beinn Iaruinn. The correctness of this opinion may, I think, be disputed.

The mounds may not be a true delta in the sense of having been deposited by a river in a sea or lake, but the materials of which they are composed bear a much greater resemblance to what is deposited by a river than to the piles of stones of a terminal moraine. There is, in fact, no piling of stones to be seen anywhere among the mounds. Where cut into they show a mixture of condensed silt with fragments of stone. These fragments are more angular than they would have been if rolled for a score of miles by the current of a river. They were merely brought from the mountains immediately around.

Opposite the mouth of Loch Treig, across the Spean above Tulloch Station, we have a fine example of a terminal moraine. It is almost one pile of stones, and along the Sliabh Lorgach, between the loch and the river, we have a succession of lateral

Digitized by Google



Digitized by Google

moraines of much the same character. In these stones predominate.

In the Glen Turret mounds, on the other hand, the silt-like material greatly predominates. The bed of the Turret shows a large quantity of rounded stones and coarse gravel, but nothing similar to the Glen Spean moraines. The Turret mounds have a much greater resemblance to those at the mouth of Loch Treig, which undoubtedly are not moraines.

The mounds in Glen Turret are, besides, cut off by a large hollow from what would be the chief source of the supposed glacier. This hollow is about a mile long by half a mile wide, and at the lower end some 90 feet deep. It was evidently at one time a lake, for the detrital matter towards the Roy is cut through by a narrow gap, affording passage to the Turret. This gap was evidently cut by the water of the lake. It is quite narrow and the banks are steep.

Before it was the bed of a lake this hollow must have been filled with ice. Ice alone could have excluded from it the material which formed the mounds. It was no subsequent wash-out by the Turret, which now flows through it. I have known part of the bottom of the hollow under cultivation, and the greater part of it might be cultivated. A wash-out would leave the bottom only stones and shingle as is the river bed.

Towards the Roy the mounds present a succession of faces about 90 feet high at the lower end, steep and sharp-edged, somewhat resembling heaps of road-repairing material squared up and ready for use. These faces have not been formed by the action of the Roy. The material must have rested against ice occupying the space through which the Roy now flows, between the mounds and the mountains to the east. In this space, about Annat, the Roy has left material resembling the Turret mounds. There are many similar deposits in the upper reaches of the Roy.

The Roy also may have contributed to the formation of the Glen Turret mounds before it sank to its present channel. The Roy Pass, at an elevation above the present river bed, points directly towards these mounds. They were the product of the Roy, the Turret and Allt a Chomhlain, which joins the Turret in the hollow described.

Digitized by Google

Along the left of this hollow there is a long detrital ridge, which can be traced from one of the upper streams forming the Turret. Only ice could exclude it from the now hollow space whose bank it follows.

Other Accumulations.

These occur especially on the Glen Roy base of Bohuntine Hill and the Spean base of the Creag Dubh, at Murlaggan. There are no streams connected with either of these hills—which have a bare, rounded outline—sufficient to account for the large accumulations of silt and sand at their bases.

In the Bohuntine case the material must have been brought down Glen Roy. The lower part of it may have been contributed to by Allt Iondruinn; but the Allt does not seem to have done much more than cut through the mass and carried the washed-away material to a lower level.

One remarkable mound rising above the general level is known as Am Bille—the "Bill," evidently, from its resemblance to a bird's bill turned up. This could never have been formed in a lake. It must have been produced in ice by a stream falling into an opening of some kind and piling up the material of which the mound is composed. The course subsequently followed by the stream to its junction with Allt Iondruinn may be traced. A narrow hollow cut out of the main detrital mass is evidently owing to its action. The Bohuntine mounds rise to the height of 100 to 120 feet above the Roy.

The Murlaggan mounds reach quite that height above the Spean. At their base is a considerable area of cultivated land in what was evidently at one time the bottom of a lake, now traversed by the Spean. The lake banks are very well marked on the south and the west sides. On the other two sides the banks were formed by the base of the large mounds. Among them is a pool, known as Uchdach Lochan, without inflow or outflow, resembling the pools at Fersit.

Only ice could have excluded the detrital material from what is now the cultivated flat. The name used at the lower end of this flat, Ceann-na-Mara—the end of the sea—would almost indicate that it was a lake till recent times. It was drained

Digitized by Google

by the Spean cutting through the detrital bank and forming the Monessie gorge.

The material forming the Murlaggan mounds appears to have been carried there partly from the direction of the Treig and the Laire. Along the heights above Inverlair, almost at the very summits, there are large accumulations of material resembling that of the Murlaggan mounds. Neither the Inverlair nor the Murlaggan detritus could have been brought to its present position through a lake, and it would be absurd to suggest that the mounds in question form lake margins.

Near Tulloch, on a much lower level, there is a considerable area of detrital material of the same character with the Murlaggan mounds. The "wash-out" caused here by a "cloud-burst" on the 9th June, 1905, gives a faint idea of what must have happened in several places by the discharge of the Lochaber Lakes, had they ever existed.

The Cols.

These lakes are supposed to have discharged their surplus water by four cols—a Glen Gloy col, a Glen Roy col, and a "Mackoul" col—into the valley of the Spey. The fourth col—that of Glen Glaster—is merely between the Roy and the Spean Valleys. Over these cols rivers are assumed to have flowed from the supposed lakes. It is admitted that no satisfactory river channels can be traced on the cols, but their absence is accounted for by the growth of moss. Doubt may be expressed as to whether any instance of moss-growing in an unobstructed river channel can be produced. Moss forms in stagnant water, and, after the water has been expelled, increases by its own growth. But a river channel over a col would be swept clean of the material necessary to form a foundation for mossy growths.

In the case of the Glen Roy—Lochan Spey col, however, no doubt can exist. How its evidence can have been overlooked by any one who has seen it is somewhat singular The visitors have doubtless been few as it is somewhat difficult of access. But here, quite close to the col, is a moraine mound which must have been partly, if not entirely, washed away by any stream of water flowing over the col; and there are several

Digitized by Google

small mounds of like kind between the col and Lochan Spey, which would show traces of any large flow of water in this direction. The flow, if there were any, would necessarily have been large, for it must have drained the Glen Gloy and the Glen Roy Lakes, and would have swept these mounds partly away.

The flow over the "Mackoul" col would have been still more formidable. It would have drained Glen Roy and Glen Spean; and the body of water passing over the col must often, during heavy rainfall and with the melting snow and ice, have greatly exceeded the present Spean at its highest flood. The work of the Spean in the gorge below Spean Bridge gives some indication of what, had there been a great flow over the "Mackoul" col, must have happened along Strath Mashie. That strath could not have its present form, and a channel would have been left towards the Spey greatly exceeding that of the Spey itself at what would have been the confluence.

In short, the more the question of flow over the cols is examined the more is evidence of its having existed found to be lacking, and such outflow was indispensable if the supposed lakes ever existed.

The Outflow of Ice from the supposed Lake Region.

During the period of the supposed lakes there was a large outflow of ice from the region which they are assumed to have occupied. Of this the evidence appears to me to be very complete. Westward from the mouth of the Spean, where the main ice barrier to the lakes is supposed to have existed, there are two glens now sending in streams into Glen More opposite the mouth of the Spean Valley. These are Glen Loy and Glen Arkaig. Loch Arkaig occupies the greater part of the latter, but it is continued westward by Glen Pean from Loch Arkaig head.

At the heads of both these glens, higher than their cols but lower than the surface of the supposed Glen Gloy and Glen Roy lakes, there are moraine lines indicating an outflow of ice in this direction. In Glen Loy there are two of these lines; in Glen Pean there are three, in both cases the one below the other. All are lateral moraines. The ice flow was contracted

Digitized by Google

in passing over the cols of these glens and there left its traces. As it advanced westward it expanded in the glens to the west of the watershed and left no moraines.

In the other two directions the indications of the outward movement of the ice are supplied by boulders and boulder lines.

About the Glen Roy—Lochan Spey col there is a large quantity of granite boulders of great size stranded upon projecting points and the more elevated parts of the moor on their way to the Spey Valley. Here the ice had, after leaving the head of Glen Roy, ample room to expand, and the boulders are widely scattered. But their positions leave no doubt, in the case of many of them, in what direction the ice by which they were borne was moving.

In the Upper Spean Valley, again, there are, over the plain lying between Loch Treig and the Spean, the long lines of boulders, so often mentioned, one within the other, concentric towards the mouth of Glen Treig. Across the Spean, above Tulloch Railway Station and opposite Loch Treig, there are masses of boulders piled over each other extending over a space of some two miles. Within the space between the loch and these lines there are many large boulders, dropped evidently by the ice as it wasted away and its onward motion ceased. All these passed through the valley now occupied by Loch Treig. They form the left wing, as it were, of a larger boulder flow, the right wing of which spread over the Moor of Rannoch, where boulders are found in huge piles along both sides of the road leading from the railway station towards Loch Rannoch. The largest accumulations are on the left of the road. On the right the boulders form groups upon the moraine mounds which stud the plain, and which would have formed islands on the surface of the moving ice sheet covering the moor.

These boulder lines within Glen Spean seldom rise to the elevation of the highest Glen Roy Parallel, and the ice movement must have gone on when the lake is supposed to have reached this elevation. The main ice movement here was towards the present Loch Laggan, and the boulders got stranded on their way thither or down the Spean Valley, as the case might be.

Digitized by Google

The Glen Gloy and Glen Spean moraines, conjointly with the boulders at the head of Glen Roy and the boulder lines in Upper Glen Spean, show that there was an outward movement of ice from what, on the lake theory, is supposed to have been a water centre. The only alternative appears to be that, after these had been deposited, the central ice, which, when the movement proceeded, must have been higher than these deposits, wasted away in the upper parts of Glen Gloy and Glen Spean and in the whole of Glen Roy, leaving at the mouth of Glen Spean and Glen Gloy an ice barrier from 600 to 800 feet deep. This appears to me an utter impossibility. While wasting away in these glens it would also waste away in the lower valley so as to allow an escape for the water produced by the melting ice. No lakes would thus have been formed.

There is the further difficulty that ice must have issued from Glen Spean to form the Spean Bridge—Auchandaul moraines already described after the glen had been cleared of ice to make room for a lake. Such a renewal of ice in Glen Spean as this implies is highly improbable.

Nothing has here been said of the mountain range to the south of Glen Spean. All that is necessary to say is that it is higher than the mountains to the north, and that, except through Glen Treig, there is no outlet. It has been shown that, instead of an outflow by this valley, there was a large flow of ice through it into Glen Spean.

III. Alternative Solution of the Parallel Road Problem.

The space at my disposal does not allow of my going more fully into the difficulties which attend the view that the Parallel Roads are the beaches of lakes formed by a barrier of ice at the mouths of the glens which now find an outlet into Glen More and hence into Loch Linnhe. I can only indicate briefly how, in my opinion, the parallels may be accounted for.

Rendu, in his Glaciers of Savoy, points out—what others have also observed—that glaciers in narrow valleys are "hog-backed." The middle of the glacier is higher, in general, than the sides. Various causes account for this vertical rounding of the glacier. Among them are the more rapid melting away of the margins by the heat of the sun reflected from the

Digitized by Google

mountain sides of the valleys in which they lie, and the effects of the streams which frequently, if not generally, flow between the glacier and the mountain. These streams for the most part find their way into the crevasses which occur at intervals in all glaciers and disappear into the river which underlies the ice.

Alpine glaciers have their lateral and terminal moraines. They flow downwards till they reach the snow line, and, after passing it, proceed considerable distances towards the plains. It is by this protrusion of the great Aletsch glacier that the Märjelen Sea, so often referred to, is formed.

European glaciers, as they now exist, flow for the most part without obstruction towards the mouths of the valleys which they occupy. During the existence of the Lochaber ice cap—the greatest thickness of which appears to have been somewhat to the north-west of Ben Nevis—the outflow of the upper strata was towards the heads of the glens both east and west of Glen More. The bottom flow, as is proved by the striation of the lower rocks, was in all cases towards the mouths of the glens. In three of these glens the remarkable lines known as the Parallel Roads of Lochaber were formed. The absence of similar lines in the other glens is not more remarkable than their absence in long stretches of the glens in which they exist. At all events, their absence in any glen is not more remarkable under one explanation of the origin of the "roads" than under another.

As already shown, I do not consider the lake theory of their origin satisfactory, and have been driven to adopt another explanation. I suggest therefore that they have been formed along the ice margin, in the hollow between the ice and the mountain sides, while the ice was wasting away in the various glens.

Wherever the ground was somewhat steep and afforded good material for their formation, the "roads" are well formed and very distinct. There are many good examples of this throughout their length. One example is a section of about half a mile long, within a short distance of the col at the head of Glen Roy. It is part of the highest Glen Roy line; shows only on one side of the glen, and does not appear again for

Digitized by Google

over a mile. Were it part of a lake margin this, from the nature of the ground, would hardly be possible.

Where the ground slopes very gradually the "roads" do not appear. The ice in these parts would slope gradually also to a thin margin unfavourable to the formation of a terrace. This is well seen opposite the short section just mentioned. It faces Lùb Chonnail, which, as already stated, is a comparatively flat plain rising very gradually on the north side. Here a lake would, from its position, pile up mounds of sand and gravel. The ice, on the other hand, wasting away, would become very thin and allow descending material to wash over it. There is therefore neither gravel nor terrace.

The thinning out of the ice will account for the absence, for long distances, of the Glean Spean "road" on the south side, above Inish and on both sides of Allt nam Bruach. There are other parts where the absence of "roads" may be similarly accounted for, and where a lake margin would be sure to show. If Glen Spean had been a lake the absence of signs of its margin for so great a distance as between Craigbeg on the Spean and "Mackoul" col—good 10 miles—cannot be accounted for. The absence here of "roads" as a formation along the ice margin, except as on the ground already explained, would require more investigation than I have been able to give to this part. I merely emphasise the fact that the absence of the "roads," regarded as lake margins, is as difficult to account for as their presence.

The Main Roads.

The question will be asked, why are the main "roads" nearly on the same level with the cols? The answer is much the same in accounting for an ice margin as for a lake margin formation of the "roads"—there was a block at the mouth of the glens. But the block was of quite a different character from that required to form a lake. In order that the roads might be formed at the ice margin, the block required need not exceed a rise of the ice surface of some 10 or 12 feet. There need not, indeed, have been a complete block at all. The collected water, when the trench between the ice and the mountain side was not large enough to contain it, may have discharged over

Digitized by Google

the ice. All that would happen would be some damage to the surface ice, which was being wasted away otherwise.

In the case of lakes a barrier about 1000 feet thick would be required for Glen Gloy and Glen Roy, and a barrier 600 to 800 feet thick for Glen Spean, at the present Spean Bridge. The main "road" in Glen Gloy and the higher "roads" in Glen Roy end very nearly in the same line. The barriers also would need to be in a continuous line. The Glen Roy barrier would be nearly as high as the top of Bohuntine Hill, and could not, under any weather influences, exist without a backing of the same height in Glen Spean.

In some strange manner this barrier, of nearly two miles long within Glen Roy, rising to an elevation of some 1200 feet above sea-level, is supposed to have given way, leaving Glen Spean a lake with a barrier nearly 4 miles long across the mouth of the valley, rising to an elevation of at least 900 feet. The depth of the lake behind the Glen Roy barrier, when at its highest, would be quite 700 feet; the depth at the Glen Spean lake would not be less than 600 feet. And these lakes are supposed to have lasted for centuries, probably, behind frail barriers of ice, which shift position as may be required.

The Glen Gloy lake would be as deep as either of the others—at all events as deep as that of Glen Spean. Whether its barrier cleared away at the same time with its Glen Roy end is not suggested in any of the statements of the case which I have seen.

Under these barriers, as under the ice originally occupying the glens, there would, of course, be an ice river, forming a large tunnel, which would allow a pressure upon the ice above it proportionate to the depth of the lake. This would not be under 300 lbs. upon the square inch—an enormous disruptive power to be withstood by ice.

The minor lines have no cols. They cannot, therefore, be supposed to be of lake formation. They must in some way be owing to ice alone. Formation at the ice margin would account for the minor lines in Glen Gloy and in Glen Roy. In this way also the perplexing problem of the Glen Co-Laraig lines may be solved.

There still remains the question how the "roads" at the

Digitized by Google

levels of the cols are so much better formed and more distinct than the others. If the minor lines are owing to ice alone, lines that at one end are owing to a barrier of earth and rocks are likely to be more marked. Whatever water within these glens could not find its way through crevasses into the sub-glacier river in each glen must have accumulated till it reached the col. This would happen again and again as the ice cap was wasted away and renewed. The annual precipitation—rain and snow—at Fort-William would produce about 70 feet of snow. The average fall on Ben Nevis would produce 150 feet. Taking the average annual snow production at 70 to 120 feet above the surface of the undecomposed ice, it must have often during the wasting-away process overtopped the cols and drained away slowly on either side as it melted. The water thus produced would not probably escape with sufficient rapidity by the sub-glacier river. It would collect for a time on the glacier surface, lap the cols, and deposit upon them the material which formed the basis of the subsequent peaty growth. The quantity of earthy matter in the hollows between the ice and the mountain sides would be increased from period to period or from year to year. It would overlap the ice along the glacier margin, and so preserve what was underneath it after the purer ice had sunk away. This detritus-covered icy shelf would endure for some time to receive further increment from above. The fluctuation of ice level and consequent increase of material along its margin will thus account for the greater development of the "roads" at the level of the cols.

Ice caps, wherever known, are found to have their surfaces almost level. Over this part of Scotland the ice may not have quite overtopped the highest mountains. Some irregularity of surface would be the consequence, and there was evidently an outward fall from some point where the ice cap had reached its greatest height—probably at the mouth of Glen Spean.

The irregularity caused by the mountain summits—due to drifting snow and other causes—would produce the irregularities in the levels of the "roads," which vary from 10 to 20 feet. These variations Professor Prestwich regards as conclusive against the idea of the "roads" being lake beaches. Taken along with the many other facts which I have stated, their

Digitized by Google

being lake margins appears to me to be completely disproved; but slight variations in level are quite consistent with an ice margin formation of the "roads."

The gradual slope of the ice cap from its highest point, somewhere about the mouth of Glen Spean, while sufficient to prevent a surface outflow from the glens towards the present Loch Linnhe, will also account for the ending of the Glen Gloy and the upper Glen Roy terraces in line. They are nearly at the same elevation, differing only 21 feet in about 5 miles, which is under 1 in 1000. The ice plane, sloping gradually from its highest elevation, would enter these glens in the line of its surface and block the outflow from the glacier margins. In this way the "roads" at that elevation would end in line. How a lake barrier could be produced to block the lakes in line I am unable to conceive.

The facts here stated are, with the fullest confidence, submitted to the consideration of competent investigators. The only conditions postulated are that regard be had to them as a whole and that they are examined on the spot. Mere map study of the questions involved is of no use. Any one forming conclusions from map study, in whole or in part, has surprises in store for him when he visits the localities.

Other Detrital Lines.

Sir Henry James, in the work already mentioned, draws attention to numerous lines, not quite horizontal, on the north side of Loch Laggan and in the Spey Valley. The Loch Laggan lines may be the substitute for the "roads" in the lower Spean Valley; or they may partake partly of the nature of the "roads" and partly of that of the Murlaggan and the Bohuntine mounds, and of the detrital accumulation near the hill tops above Inverlair.

Even if horizontal in their formation among ice, much of the original deposit may have been washed away, as has evidently been the case both at Murlaggan and at Bohuntine, but not to the same extent at the mouth of Loch Treig.

On the Roy below Bohuntine and at Achaderry there are detrital mounds, in part horizontal, and the same is the case downwards along the Spean, at Spean Bridge and Blarour, and

Digitized by Google

at Brackletter. The Brackletter plateau was no mere lake bottom. It must have been formed before the ice decayed. There are many mounds of various shapes on the Old Inverlochy plain that must have been formed among ice. They are composed of detrital material, from fine sand to coarse gravel, and chips of stone mixed with earthy material. The character of the stratification shows that the material was deposited from above. It was evidently swept by floods over the decomposing ice into the hollows that were produced by surface streams.

The Parallel Roads, and the mounds of all descriptions, whether on the hillsides or on the plains, I submit, were all produced in connection with ice without the interposition of any large lakes.

SUMMARY.

Insufficiency of the Lake Theory.

(1) The "roads" lack the characteristics of true lake beaches, and the absence of deltoid remains where the streams cross them show that they did not fall into lakes. The materials brought down by the streams were distributed over the ice, and the finer parts especially were carried forward to accumulate where shelter was found, as on the side of Bohuntine Hill.

(2) The liquefaction of ice in the higher glens would not be more rapid than at lower levels, and the formation of the required lakes above while ice remained near the sea-level would be impossible.

(3) The lake theory would require a depth of 100 feet of water within a mile of the 1151 feet col at the head of Glen Roy, while at the mouth of Glen Spean, 100 feet above sea level, there remained ice from 800 to 1000 feet thick, and similar barriers were required at the mouths of Glen Gloy and Glen Roy.

(4) These barriers of decomposing and crevassed ice would be tunnelled underneath by a glacier river, from which, owing to the depth of the lakes behind the barriers, an enormous pressure would be exerted upon the overarching ice, causing it to disrupt.

Digitized by Google

(5) Any yielding at the barriers would set in motion a large body of water, reaching back for many miles, the momentum of which would be irresistible. This moving body of water, while causing a destruction of the barrier itself, would have torn up the soil beneath, and have left in it chasms which could not be obliterated, and would now furnish evidence of such devastation.

(6) The Glen Roy barrier of over 1000 feet must have given way to allow of the forming of the Glen Spean lake, while the Glen Spean barrier—some three miles off—retained its position. Both barriers, in reality, must have wasted at the same rate, and their removal would have been simultaneous.

(7) At an elevation below as well as above that of the supposed lakes there was, as is proved by moraines and boulders, an outflow from a central region in, at least, three directions—towards the head of Glen Loy and Glen Pean to the west, of Glen Roy to the north, and of Glen Spean to the east. Ice flowed also, doubtless, eastward through Glen More and westwards towards Loch Linnhe; but these directions were unfavourable to the retention of evidence, though perhaps the "Kilfinnan Shelf," above Laggan of Glen More, may be of that character.

(8) From Glen Spean, under the 800 feet level there was a late outflow of ice towards the mouth of the valley, leaving evidence of the fact in the Spean Bridge—Auchandaul moraines, which occupy the site of the supposed main barrier.

(9) There is no trace anywhere of the devastation which must necessarily have occurred somewhere in the discharge of lakes of the supposed magnitude, or of the outflow of large rivers at high altitudes, as over the cols. The condition of the Glen Roy—Lochan Spey col proves conclusively that no large river flowed in that direction at the col level. What outflow there may have been when the col was covered with ice there does not appear to be any evidence to show.

(10) If huge ice barriers were impossible, equally so were detrital barriers. If they had ever existed there would be remains of them to-day, and such remains cannot be found. Nor would detrital slides on a scale equal to the formation of the "roads" be possible. In many parts the "roads" are

Digitized by Google

almost at the tops of banks, where sufficient material to form a slide could not be produced. The space, also, between the "roads" would not supply the necessary material to form a "road"; and there would not be successive slides, though there may have been any number of successive washings, bringing the material necessary for road formation.

The Ice Margin Theory.

(1) It is an absolute necessity arising from the circumstances that, in the wasting away of the ice cap, there should have remained in the various glens, after the mountain summits were clear, glacier-like bodies of ice, and that the ice as it lowered should be followed by detrital washings down the hillsides.

(2) These washings formed at the ice margin the collection of materials of which the roads are composed. During the wasting-away process the covering of snow must have repeatedly reached the mountain summits and been converted into ice. Hence the "roads" would from time to time receive new accessions of material. The detrital accumulations at Bohuntine, at Murlaggan, and at Inverlair differ from the "roads" mainly in magnitude, though the material of which they have been formed must have been carried further than that of which the roads are composed. A view of the Bohuntine mounds from any point a mile or two beyond Achavaddie brings out in a striking manner this resemblance. The mounds appear clinging to the mountain side on the right of the Roy.

(3) While the minor lines were produced solely by changes in the glacial surface, the main lines are owing in great measure to the obstruction of the cols. A snow or ice obstacle would soon be removed; not so a col. Hence the difference between the lines.

Period after period, and latterly season after season, the cols must have been overtopped by a succession of falls of snow, which would often be converted into ice. While this was wasting away new material would be collected on the "roads." The col would not be in any way affected as long as it retained its ice or snow covering. Over this glacial covering any quantity of water may have flowed leaving no mark of its current on the col. In all likelihood, however, the water from

Digitized by Google

the wasting snow and ice would, for the most part, find its way through crevasses into the sub-glacier river.

(4) In the case of any of the lines, as soon as the ice in which it was formed was reduced below its level at any point, the water from either ice or mountain side would escape. This lowering of the ice led to the discontinuance of the lines in various parts, as on Bohuntine Hill. It was by no means necessary that there should be a block in order to cause the discontinuance of a line. The removal of a block would be equally effective. In this way the discontinuance of the Glen Co-Laraig lines has doubtless been caused.

(5) The Glen Turret mounds, the detritus mound at the so-called Roughburn, and the Loch Treig mounds at Fersit and Inverlair were formed at the ice margin when both Glen Roy and the Spean Valley were, to the heights of the mounds at least, full of ice.

(6) Changes in the elevation and flow of the ice which formed the ice cap will account for all the "roads," mounds, and moraines in the district. The present appearance of Lochaber cannot be accounted for on the supposition that its valleys were the beds of lakes; whereas without the interposition of lakes all the varied appearances may be satisfactorily explained.

Note.—Since the proofs of this paper came to hand I have been to Lochan a Bhuic, above Inish, and on the way thither my attention was called by a friend who accompanied me to two distinct lines, apparently horizontal, on the west side of Coire 'n Eoin towards it mouth. Their elevation appeared from 1200 to 1500 feet, and their length nearly a mile.

Though often in positions from which that part of the mountain side is to be seen, I never before observed the lines. The light on this occasion was highly favourable.

Lochan a Bhuic itself is a detrital pool of small area without any stream. It is slightly above the 900 feet contour line, retained in the bend of a moraine from 30 to 50 feet high, in part a narrow ridge, in part a broad mound. On the flat plain at lower levels are various detached masses of detrital deposit that could have reached their positions only over ice.

Digitized by Google

No. XLII.—Rare Renfrewshire Minerals. By Robert S. Houston.

[Read 1st June, 1905.]

For some years past I have devoted considerable attention to the mineralogy of Renfrewshire, and, having gathered together some rare specimens found in the shire, I venture to lay a few notes on them before you. I may mention that my reason for going into this subject in what may seem a restricted aspect, viz., only the Renfrewshire minerals, was that the Paisley Naturalists' Society undertook to procure for, and present to, the local museum as complete a collection of the minerals of Renfrewshire as possible, and I was convener of the committee appointed. The first thing required, in beginning our researches, was a record of previous work done in this line. For this purpose every book, pamphlet, transaction, museum, &c., that we could hear of, and that was likely to give any information, was examined. The outcome was a table of minerals and localities which served as a working basis, and which it was now our aim to authenticate, if possible, by the securing of the minerals referred to from the localities given. It was in the prosecution of this object that the minerals I wish to refer to were obtained.

I propose to speak only on ten minerals, embracing eleven specimens, and will take them in the order used by Dana, and his numbers are adhibited.

Galena (45), *Sulphide of Lead.*—I can find no previous direct record of this species for the shire; though it is incidentally mentioned by Greg and Letsom in their Mineralogy, page 434, for, when speaking of greenockite as being found at Bishopton, they say, "associated with, occasionally, galena." Heddle, vol. i., page 24, quotes this reference in the same connection, but neither of these authorities quotes galena specifically as being found in the shire.

The specimen I now describe was found as a small boulder

Digitized by Google

lying on the rock at a depth of about 15 feet from the surface, in a cutting on the new Dalry railway, near Drygate Farm, Howwood. As it occurred as a boulder, I did not know whether it should be reckoned a Renfrewshire species or not, so I wrote to Mr. Goodchild asking his opinion, and he kindly replied as follows:—"I never could make up my mind what one should do in the matter of boulders in counties with local records. If we go on the assumption that we accept proper to the locality all the minerals that occur there as a result of natural causes, which seems a reasonable thing to do, then your galena, with its accompanying cerussite, should count as Renfrewshire minerals." I have therefore included it in my list. This is not the only record of a boulder of galena being found in this neighbourhood. In the Hunterian Museum a specimen of galena is shown, taken from a boulder which weighed about 1 cwt., found in a gravel-bed 10 feet below the surface at the south-west corner of St. George's Place, Glasgow.

It would be interesting to hear of any other boulders of this mineral being found in this district, and the probable locus from which they have been derived.

Chalcosite (54), *Sulphide of Copper.*—This mineral has not hitherto been recorded for the shire. In the New Statistical Account of Scotland—Renfrewshire—published in 1842, reference is made under Lochwinnoch parish to the finding of "copper pyritous" at Cloak. This may mean chalcosite, although copper pyrites is now scientifically classed as chalcopyrite. The specimen I show was found at Kaim Copper Quarry, Lochwinnoch, and, when analysed, gave the following results:—

Copper, - - - - -	72·36 per cent.
Sulphur, - - - - -	20·10 ,,
Insoluble, - - - - -	6·30 ,,
	98·76 per cent.

There is a slight loss here. The quantity available for analysis was small, but it proves that no other metal is present in any special quantity. Antimony was specially tested for, but was not found.

Kaim Copper Mine seems to have been started about 1848 and

Digitized by Google

gone on intermittently till 1877. It was worked by a vertical shaft about 10 to 12 fathoms deep, and then along lodes. In 1861, in eight months, about 600 tons of dressed ore were shipped *via* Troon to Swansea. In several reports and letters which the proprietor kindly allowed me to peruse the ore is referred to as grey copper ore and grey sulphuret of copper. It is surprising that no report of this mineral has hitherto been made in scientific publications.

Blende (58), *Sulphide of Zinc.*—This species has not hitherto been recorded for the shire. The specimen I describe has been forwarded to me by Mr. John Smith, Monkredding, who found it in West Quarry, Craigenfeoch, near Johnstone. On analysis I found it to be almost pure sulphide of zinc. As I wanted to be quite sure on the matter, I sent a small portion to a brother chemist, Mr. John Traquair, Glenfield Starch Works, Paisley, who replied as follows:—"I have now examined the crystal of blende you sent me, and have to confirm your result, that it is blende, ZnS. As I had only ·2 gram to work on, it was difficult to get an exact result; but I would say that it contains 90-95 per cent. ZnS., 1-2 per cent. iron and alumina, and traces of lime, magnesia, and insoluble. In fact, I would pronounce it nearly pure zinc sulphide."

I find the following statements in the Society's *Transactions:*—Vol. iii., page 29, Mr. Wallace Young says—"In a trap dyke at Fairlie a white crystalline carbonate of iron, magnesia, and lime is found, which contains some very small brownish-black crystals, which were found to consist of sulphide of iron and zinc."

Vol. vi., page 130—"Mr. John Young showed specimens of dolerite from Kirkcaldy, coated with large crystals of the hob-nail form of calcite and of blende."

Vol. ix., page 78—"Professor Heddle records blende as being associated with zeolites from the Campsie Hills."

Professor Heddle also, in his Mineralogy, vol. i., page 22, mentions that blende with calcite is found in Dockra Quarry, Beith.

These quotations show that blende is widely distributed, though in small quantities. It has been found all round the shire, but not hitherto in it.

Digitized by Google

Aragonite (277), *Carbonate of Lime.*—Previous References.

1842. New Statistical Account of Scotland, Renfrewshire, pages 84 and 148.
1876. Catalogue of Western Scottish Fossils, page 157.
1901. Heddle's Mineralogy, vol. i., page 142.
1901. Fauna, Flora, and Geology of the West of Scotland, page 550.

This mineral has been recorded from four localities, but I have not yet seen it from any of them. The New Statistical Account of Scotland, Renfrewshire, page 84, says, "It is found at Linthills, in Lochwinnoch parish," and page 148 "in Paisley parish; in many situations this rock (porphyry) assumes an amygdaloidal structure enclosing aragonite." The Catalogue of Western Scottish Fossils quotes "Greenock Hills," and Heddle says "Near Pollok Castle in Trap." The specimen I show was got at the excursion of this Society on 11th February at the cutting of the Dalry railway near Howwood, and consists of carbonate of lime.

Cerussite (281), *Carbonate of Lead.*—This mineral has not hitherto been recorded for the shire.

The specimen I show is associated with galena in the boulder found in the railway cutting at Drygate Farm, Howwood.

An analysis showed it to consist of carbonate of lead, and its identity has been confirmed by Mr. Goodchild.

Labradorite (319).—This mineral has been referred to twice before, both references being to the one locality, viz., the Gleniffer Hills to the south of Paisley.

Thomson, in his Mineralogy, vol. i., page 297, says—"The hills on the south side of Paisley contain a great quantity of a peculiar green stone in which labradorite supplies the place of the felspar." A specimen analysed in his laboratory from that locality gave—

Silica,	58·0 per cent.
Alumina,	27·3 ,,
Lime,	9·8 ,,
Protoxide of iron,	traces.
Soda,	2·0 ,,
Water,	1·2 ,,
	98·3 per cent.

Digitized by Google

He remarks that it was impossible to free it from all traces of hornblende. Again, the New Statistical Account of Scotland, Renfrewshire, page 148, says—"Paisley parish—Porphyry abounds with pretty large rhomboidal plates of felspar." [This seems to refer to labradorite.—R. S. H.]

But though so plentiful in these Gleniffer Hills, the Society's *Transactions* only incidentally mention it. In vol. ix., page 169, Mr. John Smith, in a paper on "The Ice Age in the Garnock Valley," says—"A little beyond Rigfoot we reach the home of the Fereneze and Lochliboside Hills' porphyrite, which is easily known wherever found by the abundant large crystals of labrador felspar it contains."

I have therefore included labradorite in the present list of specimens. The specimen is from the Gleniffer Hills south of Paisley, and the following is an analysis of it:—

Silica,	53·82 per cent.
Alumina,	28·09 ,,
Ferric oxide,	2·88 ,,
Oxide of manganese,	traces.
Lime,	3·62 ,,
Magnesia,	4·24 ,,
Potash,	2·25 ,,
Soda,	3·70 ,,
Water (ignition),	2·00 ,,
	100·60 per cent.

Pectolite (330).—This mineral has been recorded once before, by Greg and Letsom in their Mineralogy, page 216, from Bishopton, and the analysis they give is as follows:—

Silica,	52·07 per cent.
Alumina,	4·20 ,,
Lime,	32·80 ,,
Soda,	9·60 ,,
Water,	2·00 ,,
	100·67 per cent.

They remark that it is compact and fibrous in greenstone, colour yellowish white with a tinge of green.

The specimen I now refer to was forwarded to me by Mr. John Smith, Monkredding, who found it in South Quarry, Craigenfeoch, near Johnstone.

Digitized by Google

It is compact and fibrous like the Bishopton specimen, and an analysis produced the following results:—

Silica,	55·38 per cent.
Alumina,	traces.
Lime,	33·68 ,,
Magnesia,	traces.
Soda,	7·20 ,,
Water,	3·30 ,,
	99·56 per cent.

I visited the quarry and saw this mineral in considerable quantity there, a thin vein running right across the quarry.

Stilbite (443).—Previous References.

1842. New Statistical Account of Scotland (Renfrewshire), pages 84, 148, 360, 387, 411, 548.
1858. Greg and Letsom, Mineralogy, pages 162 and 163.
1870. *Trans.* Glasgow Geol. Soc., vol. iv., page 75.
1880. *Trans.* Glasgow Geol. Soc., vol. vii., page 46.
1876. Catalogue of Western Scottish Fossils, page 162.
1896. Dana, Mineralogy, page 585.
1901. Heddle, Mineralogy, vol. ii., page 91.

The New Statistical Account of Scotland records six localities for this mineral. The red variety from Lochwinnoch, Paisley, Kilbarchan, and Eaglesham; the yellow variety from Kilmalcolm; and Greenock is given, but the variety is not mentioned.

Greg and Letsom give Port-Glasgow, and they also say that a white variety is found at Kilmalcolm.

Although stilbite has been recorded from seven localities in Renfrewshire, still, it must be considered rare, as it is seldom met with, and then usually only in limited quantity.

The first specimen that I shall mention, which is of the red variety, was found near Bruntsfield Farm, 2 miles west from Kilbarchan, in a cutting on the roadside, where it is plentiful, though in small pieces. An analysis gave—

Silica,	55·02 per cent.
Alumina,	16·48 ,,
Oxide of iron,	traces.
Lime,	7·24 ,,
Magnesia,	·58 ,,
Soda,	4·46 ,,
Water (red heat),	17·00 ,,
	100·78 per cent.

Digitized by Google

This specimen has been confirmed by Mr. Goodchild.

The second specimen of stilbite (also of the red variety) I have to mention was found on the shore at Langbank. It may have been tipped there along with other material extracted from some cutting near by—the Caledonian Railway is only a few yards off.

Melanterite (751).—Previous References.

1837. Phillips, Mineralogy (Allan), page 232.
1858. Greg and Letsome, Mineralogy, page 274.
1876. Catalogue of Western Scottish Fossils, page 160.
1896. Dana, Mineralogy, page 942.
1901. Heddle, Mineralogy, vol. ii., page 181.
1901. Fauna, Flora, and Geology of the West of Scotland, page 552.

These references all record the same locality in the shire, viz., Hurlet. The first reference I have been able to find is in Phillips' Mineralogy, edited by Allan, and published in 1837. At page 232 he says—"In most cases it is produced by the decomposition of other minerals, particularly iron pyrites. In aluminous shale at Hurlet."

Greg and Letsom say—"In fibres of a green colour in the aluminous shale at Hurlet."

Heddle says—"Hurlet and many other localities."

The specimen I show is from a cutting at Staneley on the new Paisley, Nethercraigs, and Barrhead Railway, where it is associated with iron pyrites. The pyrites when analysed gave the following results:—

Sulphide of iron,	79·41 per cent.
Sulphate of iron,	3·03 ,,
Ferric oxide,	1·71 ,,
Arsenic,	·032 ,,
Insoluble,	13·98 ,,
Moisture,	1·25 ,,
	99·412 per cent.

This shows that 3 to 4 per cent. of melanterite ($FeSO_4 \times 7H_2O$) is present. It comes out as an incrustation, and when this incrustation was tested separately it was found to be sulphate of iron.

Digitized by Google

Carbonite.—The only record I can find of this mineral is in the Fauna, Flora, and Geology of the West of Scotland, which is the British Association Handbook for 1901, page 553, and the locality given is Paisley. As it is only a bare reference to locality, I thought I might include this in my list of minerals. The specimen comes from Jenny's Well, near Paisley, and I give the results of a chemical test, which was as follows:—

Carbonaceous matter, - - -	74 per cent.
Ash, - - - - -	26 ,,
Moisture, - - - -	traces.
Sulphur - - - -	not done.
	100 per cent.

The specimens that I have described will ultimately find a place in Paisley Museum.

Digitized by Google

No. XLIII.—The Geology of the Rouken Glen and its Neighbourhood. With two Plates and three Diagrams. By Peter Macnair, *Joint Hon. Secretary*, Curator of the Natural History Collections in the Glasgow Museums, Assistant Lecturer on Geology and Mineralogy in the Glasgow and West of Scotland Technical College. With two plates.

[Read 27th May, 1905.]

I. Introduction.

Through the munificence of Mr. A. Cameron Corbett, M.P., the Rouken Glen has now become one of Glasgow's public parks. The new park can now be reached by tramway. If I were asked where within easy reach of the city and in the compass of a few miles one could best acquire a knowledge of the leading principles of geological science, I could not possibly refer the inquirer to a better locality. In this glen the young geologist may gain many an impressive lesson in the destruction and reproduction of the solid land, a correct conception of which lies at the base of all geological speculations. Thus, at the waterfall and in the gorges he will learn that the stream has been gradually eating into the solid rock, and that in the course of long ages the rock has been removed grain by grain and particle by particle, to be deposited in the bed of the ocean. Again, if he will examine the rocks which are exposed in the beds and sides of the streams, and of which he will find many fine examples in the glen, he will doubtless be surprised to find that many of these rocks are filled with the shells and other remains of marine animals, thus showing clearly that at one time these hard, solid rocks must have been in the condition of soft sands and mud as they are seen to exist along the sea-shore at the present day. Near the top of the glen and on the railway he will find a totally different group of rocks, which have been formed in much the same manner as we see great beds of lava and ashes being laid down around the mouths of volcanoes at the present day.

Digitized by Google

The scope of this paper may be said to be twofold, it being intended to act both as a guide to the general geology of the Rouken Glen and its neighbourhood, and also as a contribution towards the study of the rocks of this area, as I believe that some important additions are made in it towards our knowledge of the stratigraphy and physical structure of this district.

The earliest paper which we have dealing with the structural geology of this district is that by Mr. Hugh M'Phail on "The Carboniferous Sections of the Levern Valley, Renfrewshire." This paper was published in the *Transactions* in 1869, and when it is considered that the Geological Survey map was not published till some years afterwards, it must be admitted that it is a very able paper, and was the first to indicate the general structure of the ground in this locality. Perhaps the only important point which seems to have escaped the notice of Mr. M'Phail is the relationship between the volcanic rocks and the Limestone series, a study of his section seeming to indicate that the limestones lie conformably upon the top of the volcanic rocks. He recognised, however, the synclinal arrangement of the Limestone series. This is clearly shown in the diagram accompanying his paper, and in the text he says the trough is in a line with a point near the junction of the Aurs Water with the Brock and with Upper Arthurlie Works at the lower end of Colmbar Glen, where it has been proved in the coal workings. It seems at some places to have been thrown a little out of the above line by transverse dislocations, one of which crosses it from South Arthurlie to Cross Arthurlie, and evidently causes a slight change of the basin. But in a general view this line may be considered as marking its position.

The next paper to which we draw attention is that by Messrs. Young and Armstrong on "The Fossils of the Carboniferous Strata of the West of Scotland." In the first paper, published in 1873, they deal with the Robroyston Limestone and its fossils. This paper was published about the same time as the issue of the Geological Survey map, and the Robroyston Limestone is taken as the line of demarcation between the Millstone Grit and the Carboniferous Limestone series to the north of Glasgow, while the Arden Limestone found at Thornliebank, Pollokshaws, and Barrhead is considered to be the equivalent to the south of

Digitized by Google

the Robroyston on the north. It is pointed out that the fossils are principally found in the shales associated with the limestones; usually the fossils are found in a broken, crushed, and fragmentary condition. It is inferred from the absence of corals and polyzoa that the Robroyston Limestone must have been accumulated in water of moderate depth.

In a subsequent paper the same authors give a description of the Orchard Limestone and its fossils, as it is seen to the south of Glasgow, where it is also known as the Lyoncross or Williamwood Limestone. This bed is known as the Orchard Limestone, because it had long been worked as a valuable cement on the farm of Orchard, near Giffnock. Operations have been discontinued in this locality for some time; but while the cement stone was being quarried the shale beds in association with it yielded a very large number of species to the collectors in the West of Scotland. The following quotation from this paper gives the succession of the Upper Limestone series as they were then believed to occur in the neighbourhood of Glasgow:—"Taking the index or Cowglen Limestone of Pollokshaws district as the lowest limestone of the Upper Limestone series of the Clyde Coal-basin, we have in ascending series over it, first, the thick-bedded sandstones of the Giffnock and Bishopbriggs quarries; second, a little higher in the series, the Orchard Cement Limestone and shales; and third, the Arden and Robroyston Limestone on a still higher horizon, the latter being made the boundary stratum between the higher beds of the Carboniferous Limestone and the Millstone Grit group. This upper group of limestones, with their accompanying strata, forms a well-marked division between the overlying Millstone Grit on the one hand, and the underlying coals and ironstones on the other, these latter in their turn resting on the lower group of Carboniferous Limestone strata. The stratum of the impure cement limestone found overlying the sandstone of the Bishopbriggs quarries north of the Clyde is believed to be the equivalent of the Orchard Limestone; but with the accompanying shale is much more ferruginous and arenaceous. It is held in little esteem as a cement, only a small quantity having been brought to market; but, nevertheless, is laid aside in heaps at the quarries, with the expectation that should richer cements

Digitized by Google

become scarce in the district it might rise in value." These writers suppose that when the limestones were accumulated the land surface lay to the north, and that the sandy character and thinness of the limestone at Bishopbriggs, compared with that at Orchard, was accounted for by supposing that the former was accumulated in shallower water than the latter. Messrs. Young and Armstrong also pointed out in this paper that the upper thin band of cement-stone seen at Bishopbriggs is characterised by the presence of *Myacites* and *Pinna* in the erect position in which they lived in the deposit, while they are absent in the lower bed, as well as in the limestone at Orchard. I have, however, since found erect specimens of *Myacites* in the Orchard Limestone where it was exposed in the railway cutting at Whitecraigs.

A great advance in our knowledge of the stratigraphy and structure of the Limestone series as seen to the south of Glasgow was made by Captain Stewart in his paper published in 1881, entitled "Notes on the Limestones in the Parishes of Cathcart and Eastwood, Renfrewshire." This paper is intended to correct the 6-inch Geological Survey map, and was founded on a large number of bores that had been put down since the Survey had been made. It is certainly an improvement on it, as in the Survey map the existence of the Holeburn Limestone as a separate bed had not been recognised, it having either been confounded on the one hand with the Cowglen Limestone below, or on the other with the Orchard Limestone above. Further, the structure of the ground in the neighbourhood of the Rouken Glen is more clearly brought out, as the different limestones are traced round the basin, and are shown to outcrop in their proper relative positions. Towards the end of the year 1894 the attention of the late Mr. William M'Innes was drawn to the fact that during an excavation made in the Thornliebank Print Works, for the purpose of erecting a gasholder, an exceedingly rich fossiliferous shale had been dug up and carted to one of the old Arden quarries about half a mile distant on the Busby and Paisley Road, and, on learning this, he proceeded there, and discovered what can be called the richest shale in fossils, particularly in rare ones, ever found in the Glasgow district. Unfortunately, the excavation had been built up before

Digitized by Google

any of the local geologists had an opportunity of seeing it. Some time afterwards I made a careful examination of the strata exposed in the bed of the Auldhouse Burn, where it passes through the Thornliebank Print Works, and was enabled to identify it and fix its position relative to a number of beds of limestone which appear near the same horizon. These limestones had formerly been considered to be the Orchard, but I was enabled to show that they are quite distinct from the Orchard, and that they occupy a horizon between the Arden Limestone above and the Orchard below.

II. Physical Features of the Rouken Glen.

The Capelrig or Auldhouse Burn, which flows through the Rouken Glen, has its source in the Brother Loch, which is situated on the great volcanic plateau which stretches southwards and covers a large part of Ayrshire, Renfrewshire, and Lanarkshire. To the east and west of the Rouken Glen similar streams descend from the same platform. Thus, on the east we have the Cleuch Burn, while on the west descends the Aurs and the Brock Burns. All these streams drain into the Cart. At the point where the Auldhouse Burn enters the Rouken Glen it has just ended its course over the great platform of volcanic rocks, and at certain seasons contains a large volume of water. At this point the burn precipitates itself over an exceedingly picturesque waterfall, the waterfall having been caused by a rocky barrier of massive sandstone. From the waterfall to where it enters the Cart the course of the Auldhouse Burn lies across a series of thick beds of sandstone, shale, limestone, and coal, and a number of fine sections can be seen in the glen. The Auldhouse Burn joins the White Cart at Pollokshaws.

The Brock Burn has a similar course to that of the Auldhouse Burn across the volcanic rocks, but lies further to the west than the latter stream. It rises a little to the west of the Brother Loch, and flows north-east across the volcanic rocks till it enters the Gorbals Reservoir at the head of the Waulkmill Glen. Here it leaves the volcanic rocks and enters upon the Limestone series, fine sections of which are exposed in the sides of the glen. At Darnley the Brock Burn is joined by the Aurs, and the united streams flow northward till they join the Levern

Digitized by Google

Water at Haugh, about half a mile to the south of Crookston Castle. The Cleuch Burn is a small stream which lies about half a mile to the east of the Auldhouse Burn, where the latter crosses the boundary fault between the volcanic rocks and the limestones. It ultimately finds its way into the Auldhouse Burn, near Pollokshaws.

The general configuration of the ground in this district has undoubtedly been largely determined by the great fault which throws down the Limestone series against the volcanic rocks, thus bringing harder and softer strata into conjunction with each other. A striking example of the influence of the geological structure in determining the scenery of a district is shown at Barrhead. Here a wedge-like extension of the Limestone series has been faulted downwards into the volcanic beds, being bounded on the west by the Fereneze Braes and on the east by the Neilston Hills. Along the area of softer strata the Levern has cut a deep valley into the surrounding rocks. On all sides the streams descending from the volcanic moorland have trenched into the sedimentary rocks, the latter rolling up gently towards the more hilly ground formed by the interbedded igneous rocks.

III. The Upper Carboniferous Limestone Series.

The volcanic rocks which appear at the head of the Rouken Glen are interbedded with the Carboniferous rocks, and near the top of the series pass into fine volcanic tuffs which eventually graduate into fine sedimentary material. This passage has been traced in the neighbourhood of Beith and Stewarton, but in the neighbourhood of Rouken Glen, as has already been pointed out, the younger sedimentary rocks are everywhere separated from the volcanic series by faulting. The Carboniferous Limestone series in the West of Scotland has been divided into an upper and lower group, they being separated by what is known as the Lower Coal and Ironstone series. The sedimentary rocks seen in the neighbourhood of the Rouken Glen, and which are the subject of this paper, all belong to the Upper Limestone series. The strata in this division consist of beds of sandstone, shale, limestone, coal,

Digitized by Google

and fireclay. There are at least five well-defined beds of limestone. The whole series varies from 80 to 100 fathoms in thickness. The organic remains are numerous and often finely preserved, they being most commonly found in the shales and limestones, and consist of plants, foraminifera, corals, crinoids, crustacea, polyzoa, mollusca, and fish remains. The accompanying diagram gives the principal limestones and their relative position to each other. At the bottom of the series is the Cowglen or index Limestone, so called because it points to the coals and ironstone which lie immediately below it.

Cowglen Limestone.—This limestone outcrops to the west of Pollokshaws, it being exposed in the "sheep park" between the village and the river Cart. In the neighbourhood of Cathcart the outcrop has been drawn in a north-easterly direction behind the parish church, and in a southerly direction from near Cathcart Bridge to Linn House. Mr. Stewart says that near Linn Bridge the limestone used to be worked opencast on both sides of the river, and Mr. Allan, the forester, who lives close to the old workings, told him that at one time there was an "ingoing eye" or subway driven from near the Linn waterfall to the workings behind New Cathcart. East of Linn gardens nothing is known of the limestone. To the south of Bogton House the Cowglen Limestone is brought in by a fault of about 35 fathoms with a downthrow to the north. From this point it stretches to the south of Overlee Farm, where it abuts against the boundary fault, bringing in the underlying volcanic rocks. On the west the Cowglen Limestone stretches from Cowglen on the road between Pollokshaws and Hurlet, and runs by Nitshill and Boghall to Barrhead.

Holeburn Limestone.—At a distance varying from 31 to 39 fathoms above the Cowglen Limestone, and from 22 to 29 fathoms below the Orchard Limestone, occurs a bed of limestone discovered by Captain Stewart of Williamwood, and named by him the Holeburn Limestone. The Officers of the Geological Survey do not seem to have been aware of the existence of this seam when they mapped this area, as has already been pointed out, confounding it on the one hand with the Cowglen below, or on the other with the Orchard above. This bed has a fairly continuous outcrop round the basin, which has already been

Digitized by Google

referred to. It has been traced from the vicinity of Eastwood by Braidbar and Williamwood; bending round to the south of Clarkston Station, it then outcrops in a roughly parallel line with the boundary fault, which separates the sedimentary and volcanic rocks, passing through Carrolside and Cleuch Farms, and abutting against the fault somewhere to the west of the Kilmarnock Road. In a subsequent part of this paper we shall see that there is a well-marked basin of strata lying to the south-east of the large fault which runs from Barrhead towards Pollokshaws, and that round this trough there outcrops in succession the Holeburn, Orchard, Rouken, and Arden Limestones. A section of the Holeburn Limestone was long exposed in the Holeburn, north of Merrylee Wood. It was also exposed in the Eastwood Cemetery, and underlies the sandstones exposed in the Burnfield, Giffnock, and Braidbar quarries. Between the centre of the basin and the volcanic rocks it was exposed at Carrolside Farm, and can still be seen in the Cleuch Burn, where its relationship to the overlying sandstones and the Orchard Limestone was clearly made out when the railway was being made. The Holeburn Limestone varies in thickness from 1 foot 3 inches at Arden to 1 foot 1 inch at Orchard, and generally has one or more partings.

So far as I am aware, the strata lying between the Cowglen and the Holeburn Limestones have not, in this area at least, yielded any great quantity of fossils; but when we pass into the overlying limestones, shales, and sandstones, we enter some of the most prolific horizons in the Carboniferous rocks of the West of Scotland.

The Giffnock Sandstones.—Having already described in a paper contributed to this Society the principal geological features of these sandstones as they are shown in the Giffnock quarries, it is scarcely necessary that anything further should be said regarding them; but, for the sake of continuity, a short summary is here given. They lie between the Holeburn Limestone below and the Orchard above, and outcrop in a continuous line round the basin. They are, of course, best seen in the Burnfield, Giffnock, and Braidbar quarries on the north side of the basin, and in the Whitecraigs and Hillfield quarries on the south side. The sandstones as seen in the

Digitized by Google

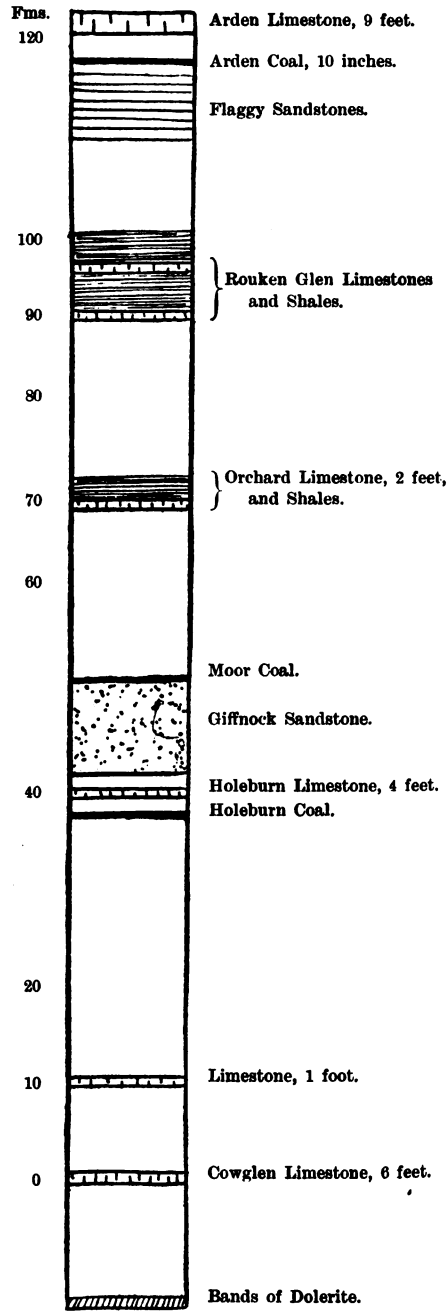


FIG. 1. Section of Upper Limestone Series in Rouken Glen District.

Digitized by Google

Giffnock quarries may be divided into an upper and lower series, the former being known to the quarrymen as the moor rock and the latter as the liver rock. The liver rock presents a remarkable uniformity of texture, and for this reason has been much prized as a building stone. This has been explained by supposing that they were accumulated in comparatively deep water beyond the influence of the tides or currents. The moor rock, on the other hand, presents a considerable diversity of character, irregular beds of grit appearing in it, which approach a conglomerate in certain places where they lie upon the liver rock, and from which they are usually separated by a strong line of local unconformity or erosion. This line of local unconformity shows evidence at many places of having been an old land surface, as a bed of fireclay and coal is frequently met upon this horizon. A fine section showing these was exposed some years ago in the Braidbar quarries, and has been described by me in my paper on the Giffnock Sandstones. This bed yielded the following plant remains:—

Asterocalamites scrobiculatus. Schl., sp.
Sphenopteris elegans. Bgt.
,, *subtrifida.* Stur.
,, sp.
Calymmatotheca stangeri. Stur.
Rhodea (sphenopteris) moravica. Elt., sp.
Dactylotheca aspera. Bgt., sp.
Sigillaria taylori. Carr, sp.
Lepidodendron veltheimianum. Sternb.
,, *rhodeanum.* Sternb.
,, *jaschei.* Roemer.
Stigmaria.

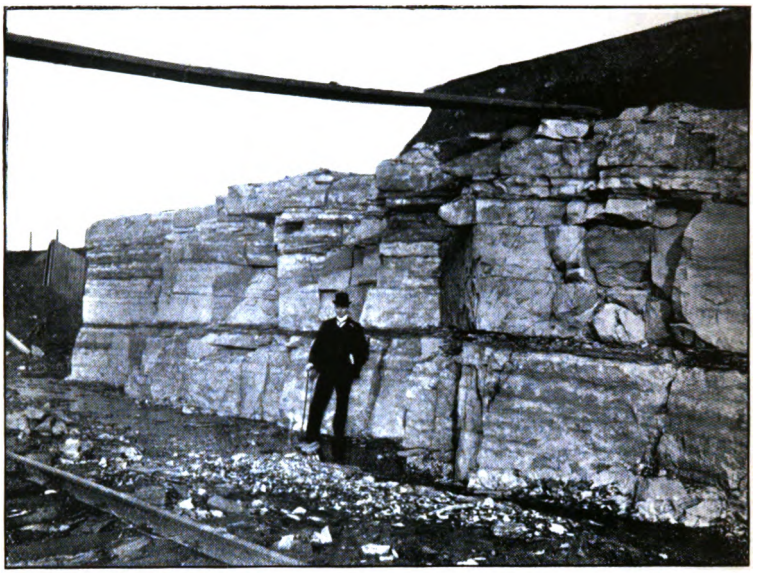
A number of erect stems of trees, probably *Lepidodendron veltheimianum,* were also found in this horizon. This coal-bed has been traced at intervals round the basin, having been worked at the head of the Rouken Glen by an adit level, which can still be seen. Near the top of the moor rock a series of shales were exposed in the Braidbar quarries containing *Discina nitida* and *Lingula mytiloides.* It is interesting to note that as the Giffnock Sandstones are traced towards the south side of the basin they become much coarser, passing into grits and fine conglomerates.

Digitized by Google

Orchard Limestone and Associated Shales.—The Orchard Limestone and its associated shales succeed the Giffnock Sandstones in ascending order, and, like the strata already described, come to the surface in an almost continuous outcrop round the north-east and south side of the basin, the western side having been somewhat broken up by the faults that have already been referred to, and which bring in strata lying below the Cowglen Limestone. This limestone was exposed to the north-east of Kennishead, near Alma Villa, and from that point has been traced westward to Orchard Farm, where it was long wrought opencast and in pits, this being the locality where so many fine fossils have been collected. Captain Stewart, in referring to the position of the outcrop between Kennishead and Orchard, says, "Its position between these points, as laid down by the Survey map, may be right, but if, as I am told by Mr. James Jackson of Sheddens, the retaining walls of the filters at Thornliebank Print Works are found in limestone rock, it may turn out not to be correct." In my opinion, the outcrop, as laid down by the Geological Survey, is perfectly correct, and the limestone found in the Thornliebank Works belongs to a higher horizon, whose existence has not been recognised either by Captain Stewart or by the Officers of the Survey. But I shall refer to this matter presently. From Orchard the position of the limestone has been correctly drawn by Captain Stewart. He shows it curving round by Clarkston Station, and then running roughly parallel with the boundary fault as far as Whitecraigs Station. Here the Orchard Limestone was exposed some years ago when the railway was being made, and was seen in its proper position above the Giffnock Sandstones of Whitecraigs quarry. From Whitecraigs Captain Stewart has joined up the Orchard Limestone with the bed seen in the Rouken Glen, near Thornliebank House. This, I think, is an error, as I believe that the latter bed is quite a different limestone upon a higher horizon, and is, in fact, the same as that which I have already mentioned as having been seen in the Thornliebank Print Works. The Orchard Limestone appears near the head of the Waulkmill Glen, and is there seen to be underlain by the Giffnock Sandstone and Holeburn Limestone. The Orchard Limestone varies in thickness from 18 to 30 inches, and in certain areas it is

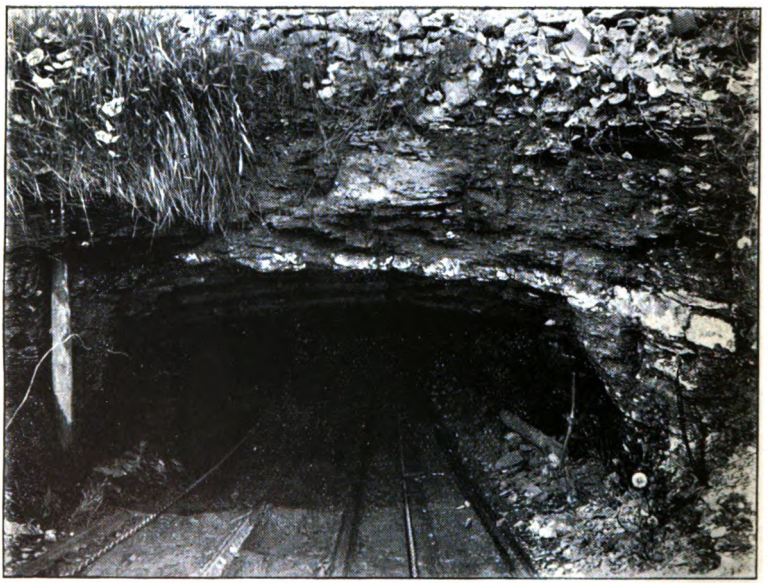
Digitized by Google

Digitized by Google



From Photo. by P. Macnair.

Arden Limestone, Darnley.



From Photo. by J. W. Reoch.

Estuarine Shale, with Marine Shale and Limestone, above Mouth of Darnley Fireclay Pit.

Digitized by Google

separated into two bands by a thin parting of shale. When the exposure was made at Whitecraigs Station this division of the limestone by a stratum of shale was clearly shown. It is also to be seen in the Waulkmill Glen and in the railway cutting north of Nitshill. The Orchard Limestone, which is known commercially as a cement or calmy limestone, is not rich in fossils, but the overlying fossiliferous shale, as has already been pointed out, has yielded an abundant fauna. The shale is of a dark bluish-grey colour, and forms a comparatively thin bed, which passes upwards into a dark slaty shale, from which few fossils have been obtained. Messrs. Armstrong and Young, in their paper on "The Fossils of the Orchard Limestone," have pointed out that the Orchard shale is rich neither in species of crinoids, corals, nor polyzoa, its characteristic fossils being shells of the univalve and bivalve groups, along with Entomostraca and Foraminifera, these latter groups of organisms never being so abundant in strata in which crinoids, corals, or polyzoa abound. Such being the case, it points to the conclusion that depth of water, temperature, and nature of the sediments laid down over the various areas of the Carboniferous old sea bottom may each have had their influence in regulating the kind of life that flourished over the several tracts.

It is somewhat interesting to note the presence of lamellibranchs in the Orchard Limestone standing in the erect position in which they lived. Species of *Myacites* and *Pinna* have been found in the cement stone of Bishopbriggs, and *Sanguinolites plicatus* has been found by me in a similar position in the Orchard Limestone at Whitecraigs. The shales in association with the limestone have yielded something like 66 genera and 120 species. The following are some of the more common species that have been collected from the horizon:—*Poteriocrinus crassus, Bairdia subcylindrica, Cythere cuneola, Ulrichia bituberculata, Beyrichia radiata, Kirkbya permiana, Athyris ambigua, Lingula mytiloides, Productus costatus, Reticularia lineata, Streptorhynchus crenistria, Cypricardella acuticarniata, Nuculana attenuata, N. brevirostris, Nucula luciniformis, Schizotoma carbonarius, Pleurotomaria frenoyana, Ptychomphalus monilifera, Baylea yvanii, Waagenella leveilleanus, Conularia quadrisulcata, Actinoceras giganteum,*

Digitized by Google

Orthoceras subcentrale, *Tomodus convexus*, and scales of *Rhizodopsis minor*.

The Rouken Glen Limestones and Shales.—At a distance of about 20 fathoms above the Orchard Limestone there occurs another group of limestone and shales which, as I have already pointed out, have been generally confounded with the Orchard Limestone. I have drawn attention to the circumstances under which this bed was first discovered by the late Mr. William M'Innes some years ago, when excavations were being made in the Thornliebank Print Works for the foundations of a gasometer. When the gasometer was being made the shale upon which its foundations were laid had been dug up and carted to one of the old Arden Limestone quarries about half a mile distant on the Busby and Paisley Road. Unfortunately, the excavation had been built upon before any of the local geologists had an opportunity of examining it, but the following is a description of the shale as it was found lying in the quarry. The shale exhibits slight variations in texture, accompanied with more or less difference in the fossil contents, from which the existence of the following was inferred:—(First) From the frequency of ironstone nodules it may be inferred that there was at least one, and probably more, layers of those nodules in the section. (Second) Blocks of an exceedingly fossiliferous shale were frequently found, and from their general size it was inferred that this shale constituted a thin band of about 6 inches thickness. On one side of many of these blocks there was a thin layer of closely packed *Orthis resupinata* and very few other fossils, but whether this was the upper or under side of the fossiliferous band could not, of course, be determined. The specimens of *Orthis resupinata* were in an almost perfect condition, the shale falling from both sides of the shell. Many of the rarer Carboniferous Limestone fossils appeared to be quite abundant in this band of shale, including *Griffithides eichwaldi* and *Streptorhynchus crenistria*. (Third) There was a shale which appeared to be got chiefly in the higher parts of the bing containing perfect specimens of *Spirifer bisulcatus*, both shells being in position, these were not by any means common, but great numbers of *Productus longispinus* accompanied them in the same shale. (Fourth)

Digitized by Google

There was a band of very tough shale with no stratification, which caused it to break in all directions with equal facility; it is slightly lighter in colour than any of the rest of the shales. A similar band can be seen in the Auldhouse Burn 20 yards away from the gasholder, and would apparently be near the top of the section. Fossils were rare in this band. (Fifth) There was a band of shale which when broken open always showed the brown colour of hydrated oxide of iron. The iron appeared to be in thin layers of the thickness of paper, separated by thicker layers of black shale. It lay at the lower part of the bing, and was probably put down first, and would therefore come from near the top of the section. This bed practically contained no fossils. The following is a list of the fossils found in these shales. The list was originally drawn up by Mr. J. Wise, and has been supplemented from the collections in Mr. Neilson's collection and in the Kelvingrove Museum:—

List of the Fossils found in the Thornliebank Shale.

Plantæ.

A reed-like plant apparently Calamites.

Protozoa (Foraminifera).

Actinozoa and Echinodermata.

Zaphrentis patula. Michelin.
Archæocidaris urei. Flem
Actinocrinus } mostly.
Rhodocrinus }
Poteriocrinus crassus. Mill.
Pisocrinus globularis. De Kon.
Platycrinus sp.

Annelida.

Serpulites membranaceus. M'Coy.
„ *carbonarius.* M'Coy.

Crustacea (Ostracoda).

Ulrichia bituberculata. J. & K.
Leperditia okeni. Mün.

Crustacea (Trilobita).

Griffithides eichwaldi. Fischer.

Digitized by Google

Polyzoa.

Ceriopora interporosa. Phill.
Diastopora megastoma. M'Coy.
Fenestella plebeia. M'Coy.
Glauconome gracilis. M'Coy.
Polypora dendroidës. M'Coy.
Rhabdomeson sp.
Sulcoretepora sp.
Synocladia carbonaria. Eth. Jun.

Brachiopoda.

Athyris ambigua. Sow.
Crania quadrata. M'Coy.
Discina nitida. Phill.
Lingula mytiloides. Sow.
Orthis resupinata. Martin.
Productus aculeatus. Martin.
,, *cora.* d'Orb.
,, *costatus.* Sow.
,, *longispinus.* Sow.
,, *scabriculus.* Martin.
,, *semireticulatus.* Martin.
,, ,, *var. Martini.* Sow.
Rhynchonella pleurodon. Phill.
Spirifera duplicicosta. Phill.
,, *trigonalis.* Martin.
,, ,, *var. bisulcata.* Sow.
Martinia glabra. Martin.
Reticularia lineata. Martin.
Spiriferina cristata.
,, ,, *var. octoplicata.* Sow.
Streptorhynchus crenistria.
,, ,, *var. radialis.* Phill.
Dielasma sacculus.
,, ,, *var. hastata.* Sow.

Lamellibranchiata.

Avicula lævigata. M'Coy.
Aviculopecten cœlatus. M'Coy.
,, *plicatus.* Sow.
,, *simplex.* de Kon.
Pinna flabelliformis. Martin.
Posidonomya corrugata. R. Eth. Jun.
Schizodus axiniformis. Phill.
Cardiomorpha oblonga. Sow.
Cypricardella rectangularis. M'Coy.
,, *acuticarniata.* Armstrong.
Nuculana attenuata. Flem.

Digitized by Google

Ctenodonta levirostrum. Portlock.
Nucula gibbosa. Flem.
,, *oblonga.* M'Coy.
Sanguinolites plicatus. Portlock.

GASTEROPODA.

Entalis inornatum. M'Coy.
,, *priscum.* Goldfuss.
Polyphemopsis phillipsiana. de Kon.
Schizotoma carbonarius. Sow.
Loxonema rugifera. Phill.
,, *scalaroidea.* Phill.
Macrochilina acutus. Sow.
,, *imbricatus.* Sow.
Macrocheilus michotianus. de Kon.
Hypergonia quadricarinata. M'Coy.
Aclisoides striatula. de Kon.
Naticopsis variata. Phill.
Agnesia contraria. de Kon.
Ptychomphalus monilifera. Phill.
Bucania decussatus. Flem.
Waagenella dumonti. d'Orbigny.
,, *leveilleanus.* de Kon.
Euphemus urei. Flem.
Conularia quadrisulcata. Sow.

CEPHALOPODA.

Actinoceras giganteum. Sow.
Cyrtoceras rugosum. Flem.
,, *unguis.* Phill.
Glyphioceras diadema. Goldfuss.
Nautilus globatus. Sow.
,, *biangulatus.* Sow.
Stoboceras sulcatus. Flem.
Orthoceras attenuatum. Flem.
,, *cylindraceum.* Flem.
,, *ovale.* Phill.
,, *sulcatum.* Flem.
,, *subcentrale.* de Kon.
Poterioceras sp.

PISCES.

Teeth or spines.

On the whole, the specimens in the Thornliebank shale are not very plentiful, but there is a great variety, and especially noteworthy is the unusually large number of the very rare species, and it is this characteristic which makes it so interest-

Digitized by Google

ing. Taking it all over, we think it can, without question, be called the richest fossiliferous locality ever found in the Glasgow district. We think we may also assert that the fossils are as well preserved as in any shale ever found, because they are seldom crushed, and the most of the specimens are perfect, although it cannot be said that they are always perfect after they are extracted from the shale.

The insides of the *Producti* are frequent and perfectly preserved. A considerable number of *Spirifer bisulcata* in almost absolute perfection, both valves in position, were found. Occasionally the nodules are full of fossils, and good specimens of shells, which are too fragile to be extracted with any degree of perfection, are sometimes obtained adhering to the outsides of the nodules. All the *Conularia* which have been found are filled with nodular ironstone, sometimes a small nodule adhering to the open end, and sometimes the concretion extends over the outside of the shell, thus reducing its value as a specimen.

Amongst the rare shells found in the Rouken Glen shale, perhaps the most noteworthy is *Conularia quadrisulcata*, which is the only *Pteropod* found in the Carboniferous system. Something like fifty specimens of this rare organism were gathered during the short period that the shale was exposed. The following others may be noted amongst the rare specimens, which are comparatively common:—

Zaphrentis patula. Michelin.
Serpulites membranaceus. M'Coy.
,, *carbonarius.* M'Coy.
Griffithides eichwaldi. Fischer.
Crania quadrata. M'Coy.
Sanguinolites plicatus. Portlock.
Pinna flabelliformis. Martin.
Schizodus axiniformis. Phill.
Entalis priscum. Goldfuss.
,, *inornatum.* M'Coy.
Glyphioceras diadema. Gold.
Nautilus globatus. Sow.
Stoboceras sulcatus. Flem.
Cyrtoceras rugosum. Flem.
Poterioceras sp.

A bore which was put down in the works of the Thornliebank Printing Company, Limited, Thornliebank, and of which a

Digitized by Google

journal has been preserved in the *Transactions* of this Society,* gives the succession of strata from the horizon of the Rouken Glen Limestone to the strata underlying the Holeburn Limestone. I have been enabled to determine the exact point at which the bore was put down, and from its position relative to the gas tank, from which the shales just described were taken, there cannot be any doubt that the bore includes those shales. Further, as no limestone was seen in the heap thrown down in the old Arden quarry, I conclude that the group of fossiliferous shales just described must belong to the sixth member of the bore, namely, the 33 feet 5 inches of dark blaes. This bed underlies the first limestone in the bore, and the foundation for the gas tank must therefore have been situated a little to the north of the outcrop of the limestone, as all the strata dip gently towards the south-west. Underneath I give the strata shown at the top of the bore put down in the Thornliebank Print Works, showing the Rouken Glen Limestones near the surface—

	Feet.	Inches.
1. Surface clay and stones, - - -	5	11
2. Dark blaes, - - - - - -	8	4
3. Dark fakes, - - - - - -	4	1
4. Dark blaes, - - - - - -	19	0
5. Limestone, - - - - - -	1	1
6. Dark blaes, - - - - - -	33	5
7. Limestone, - - - - - -	1	4
8. Grey fakes, - - - - - -	3	5
9. Limestone, - - - - - -	1	0
10. Fakes and hard ribs, - - - -	4	2
11. Limestone (sandy), - - - -	2	4
12. Dark fakes, - - - - - -	0	6

Some years ago I examined the section exposed in the bed of the Auldhouse Burn where it flows through the works, and from the evidence derived from the bore given above I came to the conclusion that we have here a group of highly fossiliferous shales and limestones occurring upon a horizon which has not yet been recognised in this neighbourhood.

The Arden Limestone and Associated Shales.—The Arden Limestone and its associated shales and coal outcrop are near the

* Journal of a Bore put down for water at Thornliebank, Renfrewshire, with Notes on the Strata, by J. B. Murdoch. Vol. ix., p. 207.

Digitized by Google

centre of the basin. Strictly speaking, there are two basins formed by the outcrop of the Arden Limestone—an eastern one, which may be named the Davieland basin, and a western one, which may be defined as the Darnley basin. In both of these the outcrop of the limestone is a fairly continuous one, and as it reaches a considerable thickness, 10 feet, being, in fact, the thickest bed seen in the neighbourhood of Glasgow, and as it is practically flat, the outcrop presents a broad band upon the map. This feature is well seen at present in the quarry near Darnley. Here the limestone has been worked along the outcrop for a distance of about a quarter of a mile. A similar feature is presented in the old quarry near Barrhead.

The two basins are separated from each other by the flaggy sandstones which underlie the limestone; these are well seen in the Rouken Glen near Deaconsbank and Newfield, where they roll over and dip below the Davieland basin on the one side and the Darnley basin on the other. The great fault, to which we have already alluded, truncates the north-east side of the Darnley basin, and brings the Cowglen and Lower Coal and Ironstone series into contact with the Arden Limestone.

The Arden Limestone in certain parts is fairly rich in fossils, though it is difficult to extract them. But the shales both above and below the limestone are also rich, though in a somewhat indifferent state of preservation. The following are some of the common genera which have been collected:—*Dielasma*, *Athyris*, *Spirifera*, *Rhynchonella*, and *Productus*, *Euomphalus*, *Orthoceras*, *Nautilus ingens*, and *Pleuro-nautilus dorso-cariniferus*, *Cochliodus*, and *Psammodus*.

Below the Arden Limestone, at a distance varying from 10 to 20 feet, there is a splint coal of inferior quality, known as the Auchinback coal, it having been extensively wrought on the grounds so named. The coal is underlain by a thick bed of fireclay containing abundant stigmaria; this fireclay has been wrought for a considerable time near Darnley. Resting immediately upon the top of the coal is a thin bed of aluminous shale, having a thickness of 3 inches, and which, because of the fossils it contains, is perhaps one of the most interesting beds to be seen in the Carboniferous Rocks of the West of Scotland. The existence of this bed has been known to local

Digitized by Google

geologists for at least about forty years. In 1865 the late Dr. John Young read a short notice of it before the Society, which is published in the *Transactions*.* At the same time Professor Rupert Jones described one of the organisms found so abundantly in this shale, under the name *Estheria punctatella*.† Dr. Young says other fossils accompany this *Estheria*, but they are by no means abundant. One of them has been referred to Dr. Dawson's American genus *Naidites*, others are *Modiolopsis*, *Actinopteria*, and *Productus*, and a small round tapering organism, not uncommon, may either be an *Entalis* or an *Orthoceras*, but the specimens are too obscure to be correctly identified.

Unfortunately, in this paper no description is given of the exact stratigraphical position of the shale or of its relationship to the Arden Limestone above, or of the coal below. Neither is there any account of the manner in which the fossils occur in the shale. It is quite possible that Dr. Young may not have seen it *in situ*, as it was only exposed at very rare intervals.

The next reference to this shale and its organisms which we find in the Society's *Transactions* is in a paper read in 1890 by Professor Jones.‡ The object of this paper is to amend his former determination and to place the so-called *Estheria youngii* among the mollusca as *Posidonomya punctatella*. At the same time he describes a new species of *Estheria* from the same beds under the name of *Estheria youngii*. Some further notes are contributed in this paper by Dr. Young regarding these beds. Thus it is pointed out that *Posidonomya punctatella* occurs in similar profusion below the limestone at Linn Spout, Dalry, about 20 miles from the Glasgow section at Thornliebank, this limestone being upon the same geological horizon as that at Arden. It is also interesting to note that at

* Note on the occurrence of *Estheria punctatella*, by J. Young. *Trans. Geol. Soc., Glasgow*, vol. ii., p. 72.

† Description of a new species of *Estheria* from the Carboniferous Limestone of Thornliebank, Renfrewshire, by Prof. T. R. Jones. *Trans. Geol. Soc., Glasgow*, vol. ii., p. 71.

‡ On some *Estheriæ* and *Estheriæ*-like shells from the Carboniferous Shales of Western Scotland, by Prof. T. R. Jones. *Trans. Geol. Soc., Glasgow*, vol. ix., p. 79.

Digitized by Google

Linn Spout the limestone, as at Thornliebank, is underlain by a bed of coal, and that the *Posidonomya* beds overlie the coal in a similar fashion as they do at Thornliebank.

About three years ago Mr. William Dow, a member of the Society, brought some fossils to the museum, which I at once recognised as being from this shale bed. He said that he had found them near Thornliebank, where the shale had been exposed while making a drain. These specimens I showed to Mr. Neilson, who contributed a short paper upon them to the Society. An interesting addition to the fauna of this bed was made from this locality by the addition of a *Gasteropod*, probably a *Murchisonia*, though too much flattened out to be definitely recognised, and a Brachiopod *Lingula*. The existence of a marine shale containing *Athyris ambigua*, *Productus longispinus*, and *Orthis resupinata* in close proximity to the *Posidonomya* shale was also proved by this section.

In his memoir on the Carboniferous Lamellibranchiata * Dr. Wheelton Hind has removed *Posidonomya punctatella* from that genus, and referred it to *Edmondia*, retaining Professor Jones' specific name *punctatella*. He says—"All the shells of this species that I have seen are crushed and flattened. They are very numerous, and occur in all stages of growth. The fossils are in calcite covered by a deposit of iron pyrites, a condition which is of important aid in showing that they belong to the Mollusca rather than to the Crustacea. The generic affinity is doubtful in the absence of details of the interior, but the shells have none of the special characters of *Posidonomya*, and I am quite at a loss to account for their reference to this very distinct and characteristic genus. The shells are not oblique, and have no posterior wing-like projection. For the present I place the species in the genus *Edmondia*, because there is no lunule and no escutcheon, and the hinge-line appears to be simple and erect. Whatever ligament there was seems to have been internal."

Unfortunately, when the drain was being made at Thornliebank it was not examined geologically, the specimens that were collected having been gathered after the section had

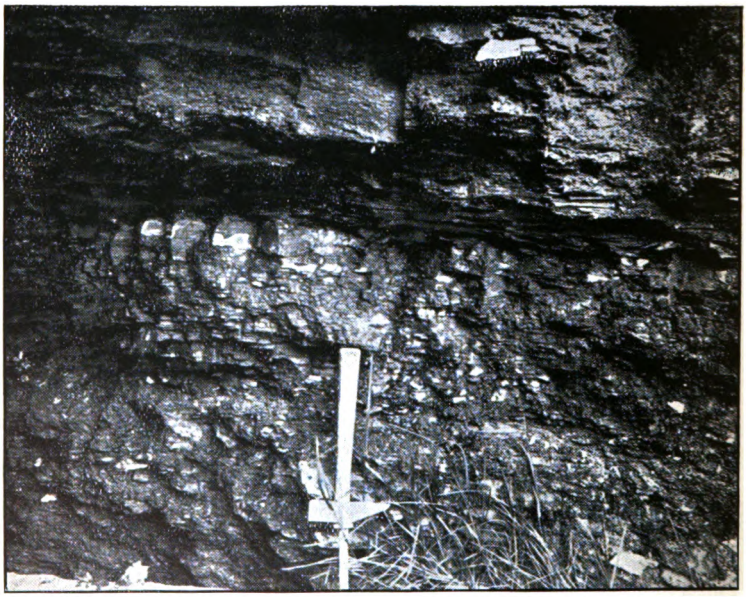
* Monograph of the British Carboniferous Lamellibranchiata, p. 147, Palæontographical Society.

Digitized by Google

Digitized by Google

From Photo. by J. W. Reoch.

Orchard Limestone and Shale, Waulkmill Glen.



From Photo. by J. W. Reoch.

Estuarine Shale, above Coal and Fireclay, Mouth of Darnley Fireclay Pit.

a Fireclay. *b* Coal. *c* Estuarine Shale. *d* Marine Shale.

Digitized by Google

been covered up, so that no clue was obtainable as to the distribution of the organisms in the shale. I have often when geologising in the Waulkmill Glen looked for this shale between the horizon of the fireclay which is exposed in the bed of the Brock Burn, and the Arden Limestone which is also exposed in the burn, and in a quarry, knowing that if the shale occurred in the glen it ought to crop out between these two horizons. Till a month ago, however, I was unsuccessful in finding it. Hugh M'Phail, in the paper already cited, mentions that the Auchinback coal is seen in the glen at a point where the stream winds round a knoll and nearly in a straight line for about 100 yards, when, by a fault, the limestone and the coal are thrown off. The outcrop of the limestone can still be traced, but the coal appears to be covered up, though its position is indicated by the fireclay and by blocks containing fragments of the coal which are lying about the glen at this point. Above what appears to be the probable position of the coal I found the outcrop of the *Posidonomya punctatella* beds, the shales containing badly preserved specimens of that fossil. There can, however, be no doubt as to its being the same bed, and Mr. Neilson, who accompanied me, was satisfied on this point. It was impossible, however, to get at the bed without a considerable amount of digging, though there is a very clear section in the glen showing the relationship of the *Posidonomya punctatella* bed both to the strata above and below it.

A subsequent visit which I paid to the glen resulted in the discovery of a clear section showing the strata from the fireclay up to the Arden Limestone without a break, and I am now enabled to lay before you the results of my examination of this section.

This section is to be seen at the mouth of the Darnley Fireclay Pit, about a quarter of a mile from the exposure just described. At the bottom of the section is the fireclay, which is 4 feet thick. Above it comes 10 inches of coal, and immediately above the coal is the estuarine shale 3 inches thick. On the top of the estuarine shale is a bed of marine shale 9 inches in thickness, and above this a bed of limestone 6 inches thick. Above the thin band of limestone we have 8 feet of shale, which passes into the Arden Limestone 10 feet in thickness. The

Digitized by Google

fireclay is full of stigmaria, and the coal contains badly preserved plant remains referable to *Lepidodendron*. The shale at this locality has yielded *Estheria youngii*, *Posidonomya punctatella*, and *Actinopteria persulcata*. A more extended search may yet reveal other species, as *Murchisonia* and *Lingula*, which were found at Thornliebank, have not yet been found by me at Darnley. The *Cypricardia*-like shells occur, but I have not been able to get sufficiently well-preserved specimens to determine their exact affinities or their distribution in the shale.

One puzzling organism which occurs in the shale, and appears to be distributed through it from top to bottom, is the long lanceolate impression which appears as a mere film on the surface of the shale. This has been recognised in all the exposures, and has been doubtfully referred to as *Orthoceras* and *Entalis*. From the evidence of the specimens which I have found in the Darnley Pit I doubt its animal origin, and feel rather inclined to look upon it as the leaves of some species of *Lepidodendron*.

A careful examination of the shale shows that for about half an inch above the coal it appears to be perfectly barren, then comes a layer of *Posidonomya punctatella* and *Estheria youngii*, the latter measuring 8·5 mm. long and 4·5 mm broad, and the former 8·5 mm. by 5·6 mm. *Estheria youngii* is very abundant in this layer. The next layer, about three-eighths of an inch above the first one, shows a considerable decrease in numbers both in *Posidonomya* and *Estheria*, but the average size of *Posidonomya* now measures 15 mm. by 10 mm. About a quarter of an inch above this comes the layer containing *Actinopteria persulcata* and *Murchisonia* in association with *Posidonomya*, and a layer about half an inch above the last-mentioned layer of *Posidonomya* contains specimens of that shell, which measure 20 mm. by 15 mm. This layer is particularly rich in *Lepidodendron* leaves, and *Estheria youngii* has now died out.

Posidonomya punctatella and *Actinopteria persulcata* continue through the remaining part of the shale, and near the top of the bed are associated with *Lingula mytiloides*. In these upper layers *Posidonomya punctatella* reaches its maximum size

Digitized by Google

of 32 by 22 mm. They no longer, however, occur in distinct layers, but appear as isolated individuals scattered through the shale.

Passing now to an explanation of the phenomena exhibited by this most interesting shale, we have at the base of the section the fireclay and coal, indicating an old land surface along the shore of a Carboniferous lagoon. Then came a period of depression, and the lagoon was flooded with fresh water, into which *Posidonomya punctatella* and *Estheria youngii* migrated. A continued sinking of the land was accompanied by an inundation of salt water, and during one of these the first layer of *Estheria* and *Posidonomya* was killed off. The water now appears to have become salt enough to have allowed of the migration of a marine fauna over the area, as represented by *Murchisonia* and *Actinopteria*. But a sudden influx of sea water killed off the well-marked layer of these shells. After this the water seems to have been gradually getting salter, and an occasional influx of pure sea water killed off similar layers of *Posidonomya*. With the increasing saltness of the water *Posidonomya* becomes entirely killed off, and another considerable depression of the sea-bed ushers in the purely marine conditions indicated by the overlying shale containing the Brachiopods, *Productus longispinus*, *Athyris ambigua*, *Orthis resupinata*, and a *Spirifer*.

It appears then that when the estuarine shale was being deposited the lagoon formed a sort of debateable ground, in which the marine and fresh-water faunas mingled for a time, but with the continual sinking of the land the ultimate victory was secured by the purely marine forms, owing to the increasing salinity of the water.

IV. Sections Exposed in the Rouken Glen.

About a quarter of a mile to the west of the new Kilmarnock Road and a little to the south-west of the Whitecraigs quarry the Capelrig Burn crosses the boundary fault between the volcanic rocks and the Carboniferous Limestone series. Near this point a bore was put down, which showed the Holeburn

Digitized by Google

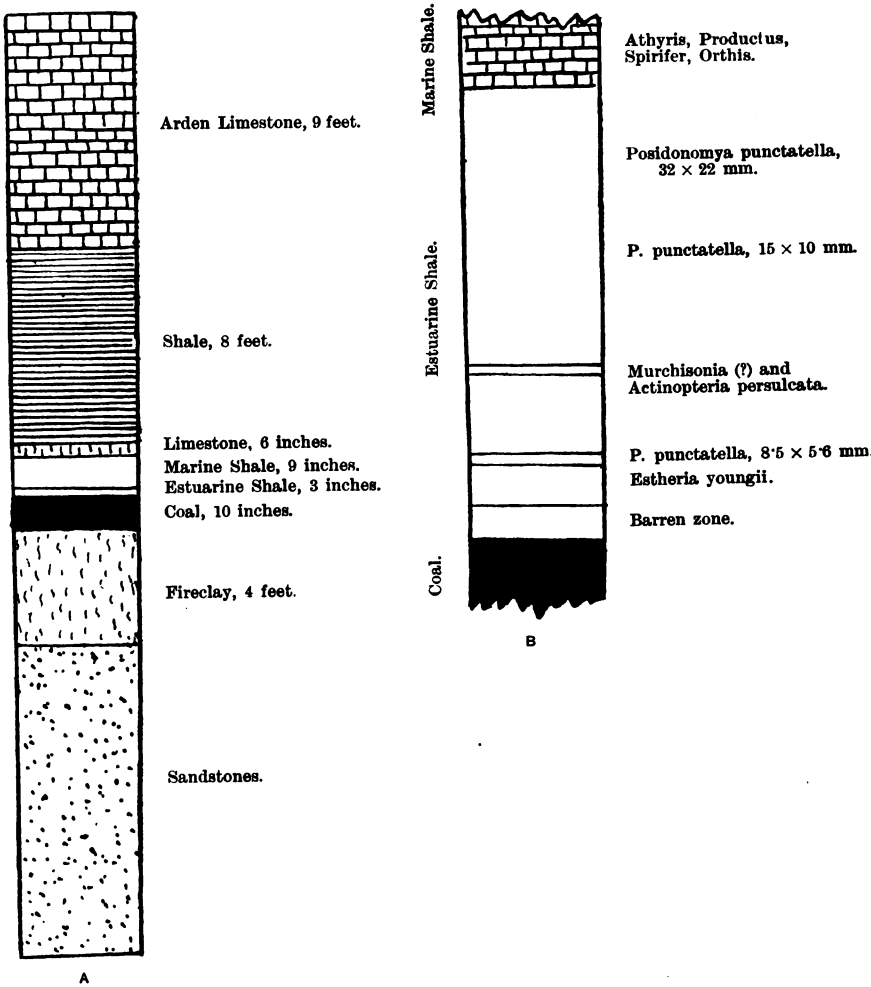


FIG. 2.

A Section showing the Estuarine Shale below the Arden Limestone and its relationship to the underlying and overlying strata.

B Enlarged Section of the Estuarine Shale showing the distribution of its fauna.

Digitized by Google

Limestone outcropping at the surface, the section to the Holeburn coal being as follows:—

	Feet.	Inches.
1. Holeburn Limestone, - -	2	4
2. Grey fakes, - - - -	4	6
3. Sandstone, - - - -	1	6
4. Grey fakes, - - - -	1	3
5. Sandstone, - - - -	0	9
6. Dark blaes, - - - -	1	6
7. Holeburn Coal, - - -	1	4

The Holeburn Limestone is also exposed in the bed of the Cleuch Burn to the east of Whitecraigs, where it is seen to dip below the Giffnock Sandstones which are exposed in Whitecraigs quarry. At this point the Holeburn Limestone is divided in two by a parting of shale 1 inch thick; the lower band is 18 inches thick and the upper 8 inches thick. Above the limestone there are 6 inches of shale and 12 feet of flaggy sandstone.

When the Lanarkshire and Ayrshire Railway was being made a section was exposed at Whitecraigs Station. The whole of this section has now, unfortunately, been covered up by the station platform. This section showed the outcrop of the Orchard Limestone in the exact position that it had been mapped by the late Captain Stewart of Williamwood. The section was exposed at right angles to the dip of the strata. Like the usual exposures of the Orchard Limestone, it cannot at this point be said to be very fossiliferous; certain bands within the limestone present a greater abundance of shell and crinoid fragments than others. Here, as has already been observed, the Orchard Limestone is characterised by the occurrence in it of numerous shells of *Pinna* and *Myacites* still standing in the erect position in which they lived. The Orchard Limestone at this point was seen to be separated by a thin bed of shale, this shale being literally crammed with the remains of crinoid stems and plates. *Euphemus Urei* and *Productus longispinus* also occur in great numbers. The shales lying above the limestone in this section are not nearly so rich in species as at Orchard.

Returning now to the section exposed in the Capelrig or Auldhouse Burn, the Giffnock Sandstones are seen to outcrop between the boundary fault and the waterfall in the Rouken

Digitized by Google

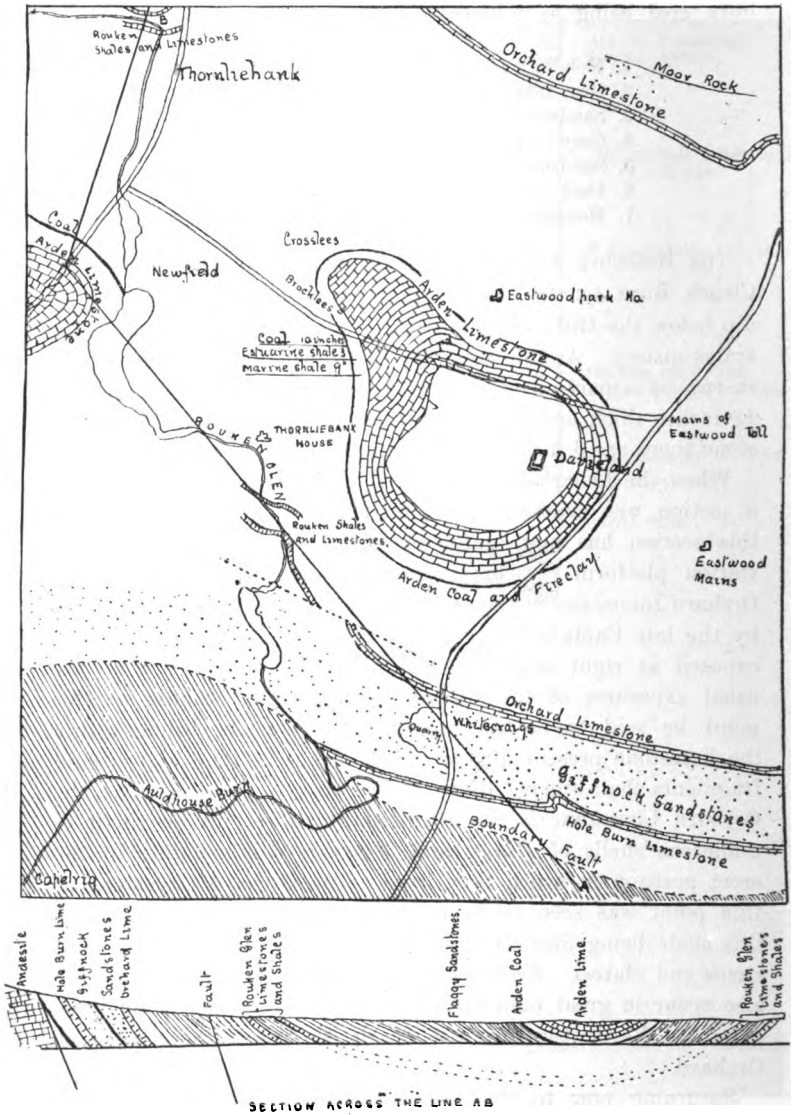


Fig. 3. Sketch Map and Section of the Rouken Glen to illustrate its Geological structure.

Digitized by Google

Glen. At the point where the railway crosses the burn the moor rock coal, with its underlying bed of fireclay, is seen to outcrop in the bed of the stream, and an ingoing eye shows where the coal was formerly wrought. Above the coal there comes a series of flaggy sandstones, which overlie the massive sandstones seen at the waterfall.

Numerous fine exposures of the Giffnock Sandstone are to be seen in this neighbourhood, and a little to the west of the present waterfall there is a gorge which probably indicates the former course of the Capelrig Burn. At the foot of the waterfall a fault occurs, which throws down the flagstones underlying the Rouken Glen Limestones against the Giffnock Sandstones, and at the same time cuts out the Orchard Limestone. The existence of the fault and the presence of the massive sandstones account for the position of the waterfall.

Below the waterfall the bed of the stream shows a series of flaggy sandstones dipping towards the north, and on the right bank the stream has laid bare a fine section of the Rouken Glen Limestones and shales. The following section is from a bore put down in this neighbourhood with the Arden Limestone at the top, and shows the general succession of the beds between the Arden and the Rouken Glen Limestones:—

Bore in Davieland, somewhere on west side of that part of the Mearns or New Kilmarnock Road, between Eastwood Mains Toll and Whitecraigs Quarry.

ARDEN LIMESTONE AT OR NEAR SURFACE.

	Fathoms.	Feet.	Inches.
1. Surface clay,	0	3	0
2. Coal,	0	1	0
3. Fakes,	2	2	0
4. Sandstone,	0	1	3
5. Fakes,	0	1	0
6. Coal,	0	1	6
7. Coal,	0	0	10
8. Sandstone,	0	5	2
9. Fakes,	1	1	4
10. Sandstone,	0	3	11
11. Sandstone plies,	0	4	6
12. Fakes with sandstone plies,	1	1	0
13. Sandstone plies,	0	3	0

Digitized by Google

	Fathoms.	Feet.	Inches.
14. Fakes with sandstone plies, -	0	3	3
15. Hard sandstone, - -	0	3	10
16. Fakes, - - - -	0	0	8
17. Hard sandstone, - -	0	1	8
18. Hard sandstone, - -	0	4	0
19. Sandstone plies, - -	0	0	9
20. Hard sandstone, - -	0	3	7
21. Sandstone plies, - -	1	1	7
22. Fakes, - - - -	0	0	6
23. Sandstone plies, - -	0	4	0
24. Hard sandstone, - -	0	2	7
25. Fakes, - - - -	7	3	6
26. Limestone (Rouken), - -	0	0	8
27. Fakes, - - - -	5	3	10
28. Limestone (Rouken), - -	0	1	3
29. Fakes, - - - -	0	0	11
30. Hard Sandstone, - -	0	2	10

Still further down the stream there are fine exposures of the sandstones, sandy shales, and flaggy sandstones which underlie the Arden Limestone, and which are shown in the bore from No. 8 to No. 24. These beds roll over and dip below the Arden basin on the west and the Davieland basin on the east. The Rouken Glen Limestones and shales pass beneath these and emerge again upon the north side of these basins, where they are seen in the bed of the Auldhouse Burn at the Thornliebank Print Works.

A clear section in ascending order can be seen in the bed of the Auldhouse Burn, where it passes through the print works. Just beneath the laboratory in connection with the works, and where the stream bends almost at right angles to the west, the Rouken Glen Limestones and shales are exposed; the limestone No. 6 in bore, given on page 379, forms the foundation of the bridge that here crosses the stream. This limestone is highly fossiliferous, but the fossils as usual are difficult to extract. Immediately from beneath this limestone comes the dark shale, whose organisms have already been described in detail. An examination of this shale shows that it must be the same as was exposed when the gasometer was being built, as it contains all the fossils which were then gathered, and they are in exactly the same state of preservation. The bed, containing great quantities of *Orthis resupinata*, has also been identified

Digitized by Google

in this section. A similar bed of shale comes out from below the limestone already described in the higher part of the glen.

Proceeding up the stream the strata is seen to dip gently towards the south-west. Above the limestone comes a series of beds of shale, having a thickness of over 30 feet, and with which is associated a seam of impure limestone. This is No. 4 in the bore already referred to. These shales are succeeded by beds of flaggy sandstones, which pass upwards into the Arden Coal and Limestone, but these beds are not exposed in the burn. To the west of Thornliebank the outcrop of the Arden Limestone can be distinctly traced in the old quarries, which were formerly extensively worked in this district.

The Arden Coal, with its associated estuarine and marine shales, has been exposed from time to time in the neighbourhood of Thornliebank. About two years ago, while making a drain to the south of Brocklees, these beds were laid bare, and some fine specimens were obtained.

V. Sections Exposed in the Waulkmill Glen.

The Waulkmill Glen lies about a mile to the west of the Rouken Glen, and presents much the same geological features as the latter. The natural sections are, however, much clearer and more continuous, and help to supplement what is wanting in the Rouken Glen. In the Waulkmill Glen there is an almost continuous section from the base of the Giffnock Sandstones to the base of the Rouken Limestones, and from the Arden Coal to the Arden Limestone. The intervening strata, including the fossiliferous shales of the Rouken Limestone series, are, however, covered by a mantle of superficial deposits, and a small fault occurs between the Rouken Limestone series and the Arden Limestone series.

At the top of the Waulkmill Glen the boundary fault is seen to pass through the Gorbals Reservoir almost in a line with the Lanarkshire and Ayrshire Railway. A cutting on the east side of the railway viaduct shows a fine section of volcanic tuff overlaid by beds of andesite lava. Immediately to the north of the Littleton Reservoir a bed of limestone was exposed during the making of the reservoir. This is probably the equivalent

Digitized by Google

of the Holeburn Limestone, as it lies immediately beneath the Giffnock Sandstones. Proceeding towards the north and entering the bed of the Brock Burn the Giffnock Sandstones are seen dipping towards the north. These beds are much coarser on this side of the basin than they are on the north side, being mostly grits which pass in places into conglomerates, containing large pebbles of quartz, thus indicating that the old land surface from which the pebbles were derived lay somewhere to the south or south-west.

The strata exposed in the glen is seen to dip down the stream, and as we proceed northwards younger and still younger rocks are exposed. The massive sandstones seen at the head of the glen pass upwards into flaggy sandstones, which are probably upon the same horizon as the Moor Rock of the Giffnock quarries. Near the top there occurs a thin bed of coal, which was formerly extensively worked in this district; it is known locally as the "Lyoncross" Coal, and is most likely the same as the "Moor" Coal of Giffnock.

About three fathoms above the coal, and separated from it by sandstones, fireclay, and a thin coal, comes the Orchard Limestone. It is divided into two bands of 10 and 22 inches respectively, which are separated by about 3 inches of shale. The Orchard Limestone is underlain by about 2 feet of sandstone, and below the sandstone is about 3 inches of coal. The thick bed of shale which covers the limestone is highly fossiliferous, and has yielded a similar fauna to that found at Orchard, and is also in much the same state of preservation. Mr. James Neilson has pointed out to me that two distinct faunas can be recognised in the shale, one of which is more intensely marine than the other.

The Orchard Limestone is at present being wrought at this point, and some fine sections have been laid bare, which afford exceptional facilities both for the study of the limestone and for the gathering of fossils. Very few fossils occur in the limestone, but immediately we ascend into the shale an abundant supply of fossils may be obtained.

Some geologists argue from the absence of fossils in these limestones that they could not have been formed by the accumulation of organic remains, and that the carbonate of

Digitized by Google

lime must have been chemically precipitated. The presence of highly fossiliferous shales in contact with the limestone seems to me, however, to disprove this theory, and I believe that it is merely a case of preservation, the organisms in the originally highly fossiliferous limestone having become replaced by granular calcite, in which the shape of the organisms has become destroyed. Certain shales, on the other hand, afford a much better medium for the preservation of fossils. I have already entered into this matter in some detail in my paper on the Giffnock Sandstones, and I find the views therein advanced somewhat strikingly confirmed in the section exposed at Whitecraigs Station. Above the Orchard Limestone at that point there lies a bed of unfossiliferous sandstone, and I found in the heart of the sandstone thin films or layers of shale yielding spiral shells and stems of crinoids, though the sandstone itself was absolutely barren of organic remains.

Returning to the section in the Waulkmill Glen, the Orchard Limestone and shales are seen to be succeeded by thick beds of shale and flaggy sandstones, which pass up into the Rouken Glen Limestone series just at the point where the glen begins to open out. The lowest bed of limestone, with its overlying shales, is exposed, but the upper limestone and the rich fossiliferous horizon is covered by alluvial deposits. A little further down the stream there are several fine sections in the flaggy sandstones and shales which underlie the Arden Limestone. At this point a small fault enters the glen, which brings down the Arden Limestone and coal against the underlying flagstones. The Brock Burn now winds round a rather picturesque knoll, which shows the flaggy sandstones passing up into fireclay, the fireclay being succeeded by the Arden Coal and its associated estuarine and marine shales. Above the shales there is a limestone 1 foot thick, which is succeeded by shales passing up into the Arden Limestone 9 feet thick. The limestone is capped by thick beds of shale seen near Darnley House at the foot of the glen.

VI. Conclusion.

In this paper I have attempted to work out in some detail the stratigraphy of the Upper Limestone series as seen in the

Digitized by Google

Rouken Glen. The Geological Survey maps stand much in need of correction, and though considerable advances were made by the late Captain Stewart of Williamwood, yet he failed to recognise the Rouken Glen Limestone series as a separate horizon, having usually confounded it with the Orchard Limestone. From what has been shown in the foregoing paper, I think that there cannot be the least doubt as to the position of this important fossiliferous horizon in the West of Scotland. The discovery of the estuarine shales at Darnley, and the clear sections which I have found there showing the beds lying between the Arden Coal and the Arden Limestone, tends to throw some light upon a most interesting series of deposits whose exact succession and mode of occurrence have hitherto been shrouded under considerable mystery. The establishment of these two horizons in the Upper Limestone series may help towards the ultimate zoning of the Carboniferous Rocks in the West of Scotland.

I have to acknowledge my indebtedness to Mr. J. W. Reoch for three of the photographs which illustrate this paper.

Bore put down from bottom of Orchard Cement Quarry, about 300 yards west of the New Kilmarnock Road, and west of Orchard Farm Steading in Eastwood Parish.

ORCHARD LIMESTONE.

	Fathoms.	Feet.	Inches.
1. Orchard cement, - -	0	0	0
2. Grey fakes (pavement of Orchard cement), -	0	3	6
3. Hard white sandstone, -	0	5	0
4. Grey fakes, - - -	0	2	6
5. Loose soft coal, Orchard cement coal, - -	0	0	7
6. Hard white sandstone, -	3	0	4
7. Grey fakes, - - -	0	0	10
8. Fakey white sandstone, -	0	3	6
9. Hard white sandstone, -	1	5	4
10. Light fakes, - - -	0	1	4

Digitized by Google

	Fathoms.	Feet.	Inches.
11. White sandstone,	2	5	7
12. Soft fakes,	0	1	0
13. White sandstone,	1	1	9
14. Grey fakes,	0	1	6
15. White sandstone,	2	4	0
16. Hard grey sandstone,	0	1	9
17. Dark blaes,	0	1	2
18. Light blaes,	0	3	4
19. Hard grey fake,	0	2	0
20. Hard grey sandstone,	0	0	9
21. Dark fakes,	0	1	0
22. Light fakes,	0	2	10
23. Dark fakes,	0	1	2
24. Hard white sandstone,	0	1	7
25. Dark fakes,	0	1	0
26. Hard white sandstone,	0	2	7
27. Dark fakes,	0	0	5
28. Very hard grey sandstone,	0	0	9
29. Dark fakes,	0	0	6
30. Fakey white sandstone,	0	3	4
31. Dark fakes and blaes,	0	1	10
32. Light fakey sandstone,	0	2	10
33. Hard white sandstone,	0	4	10
34. Soft white sandstone,	1	1	10
35. Dark brown fakes,	0	0	6
36. Brownish sandstone,	0	4	0
37. Hard white sandstone,	1	3	8
38. Fakey white sandstone,	2	1	7
39. Blue blaes,	0	4	1
40. Soft dark limestone,	0	2	2
41. Hard dark limy blaes,	0	2	0
Holeburn Limestone.			
42. Hard limestone,	0	4	11
43. Hard limy blaes,	0	1	5
44. Blue blaes,	0	5	11
45. Fakey blue blaes,	0	4	10
46. Foul coal,	0	2	10
47. Light blaes,	0	1	2
48. Light sandy blaes,	1	0	2
49. Ironstone ball,	0	0	3½
50. Light blaes,	0	2	10
51. Hard grey fakes,	0	4	0
52. Dark fakes and ironstone ball,	0	1	8
53. Light sandy blaes,	0	1	6

Digitized by Google

		Fathoms.	Feet.	Inches.
54.	Ironstone ball,	0	0	1½
55.	Light fakey blaes,	0	3	2
56.	Coarse sandy ironstone,	0	0	9
57.	Light fakes,	0	4	0
58.	Hard grey fakes,	0	4	10
59.	Fakey white sandstone,	1	0	0
60.	Hard white sandstone,	2	3	10
61.	White sandstone,	2	0	8
62.	Dark fakes and blaes,	0	2	0
63.	Foul coal,	0	0	4
64.	Dark fakes and blaes,	0	2	10
65.	Very hard rib fakes,	0	0	6
66.	Dark fakes,	0	3	0
67.	Very hard grey kingle,	0	0	8
68.	Hard white sandstone,	0	5	3
69.	Light fakes and fireclay,	0	5	6
70.	Dark fakes,	0	0	8
71.	Soft coal,	0	1	4
72.	Light fakes and fireclay,	0	2	2
73.	Hard light fakes,	0	3	2
74.	Hard white sandstone,	0	5	1
75.	Blue blaes,	0	3	4
76.	Red sulphuric fake,	0	0	2
77.	Soft coal,	0	0	7½
78.	Soft dark fakes,	0	0	4
79.	Hard white sandstone,	0	4	1
80.	Grey fakes,	0	1	8
81.	Hard grey sandstone,	0	1	3
82.	Dark fakes,	0	2	10
83.	Very hard white sandstone,	0	1	2
84.	Grey fakes,	0	2	2
85.	Hard grey fakes,	0	3	6
86.	Very hard grey sandstone,	0	2	2
87.	Dark fakes,	0	2	10
88.	Very hard grey sandstone,	0	2	1
89.	Grey fakes,	0	1	2
90.	Very hard grey sandstone,	0	1	4
91.	Dark fakes,	0	2	0
92.	Blue blaes,	0	3	0
93.	Hard limy dark fakes,	0	0	9½
94.	Blue blaes,	0	0	3
95.	Hard limy dark fakes,	0	0	8
96.	Light fakes,	0	2	1
97.	Hard light grey sandstone,	0	5	7
98.	Dark grey fakes,	1	0	5

Digitized by Google

		Fathoms.	Feet.	Inches.
99.	Dark fakes, - - -	0	1	5
100.	Light fakes, - - -	0	1	9
101.	White sandstone, - -	1	1	7
102.	Hard white sandstone, -	0	3	9
103.	Soft white sandstone, -	0	3	2
104.	Dark fakes, - - -	0	1	8
105.	Fakey blue blaes, - -	0	3	1
106.	Soft dark fakes, - -	0	0	4
107.	Grey fakes with a little iron,	0	1	2
108.	Fakey blue blaes, - -	1	3	1
109.	Blue blaes, - - -	0	1	4
110.	Ironstone ball, - -	0	0	1
111.	Bluish blaes, - -	0	2	4
112.	Ironstone ball, - -	0	0	1
113.	Dark blue blaes, - -	0	1	4½
114.	Ironstone ball, - -	0	0	0½
115.	Blue blaes, - - -	0	3	0
	COWGLEN LIMESTONE.			
116.	Hard dark limestone, -	1	0	0
117.	Fakey blue blaes, - -	0	4	8
118.	Blue blaes, - - -	0	3	6
119.	Ironstone ball, - -	0	0	1
120.	Fakey blue blaes, - -	0	4	5
121.	Dark fakes, - - -	1	0	0

Digitized by Google

PROCEEDINGS FOR SESSION 1903-1904.

(46TH SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET, 15TH OCTOBER, 1903.

Mr. ROBERT KIDSTON, F.R.S., *Vice-President*, in the Chair.

The first meeting of the 46th session of the Geological Society of Glasgow was held here this evening, Mr. ROBERT KIDSTON, F.R.S., F.G.S., Vice-President, in the Chair, when the minutes of the previous meeting (28th May) were read and approved.

Mr. R. W. DRON, C.E., M.E., exhibited specimens of Altered Coal from the colliery situated on the banks of the Clyde near Hamilton. The coal has an appearance as if it had been burnt by the presence of "whin," and is known by the miners as "burnt coal." There is, however, no "whin" associated with the adjoining strata, and the coal seams have not been affected by the agency.

An analysis shows that the coal contains from 35°/₀ to 40°/₀ of ash, which is highly calcareous, and indicates that the coal itself has about 20°/₀ of lime.

Mr. JOHN WALLACE read "Some Notes on Recent Excavations in Glasgow." [See *Transactions*, vol. xii., p. 220.]

Mr. JOHN WALLACE read secondly a paper entitled "Notes on the Spheroidal Weathering of the Trap Dyke near Bishopbriggs, about 1½ miles to the N.-E."

After describing the appearances of this dyke and its curious spheroidal decomposition, Mr. Wallace gave at some length his theories as to the cause of the latter, and attributed it to the action of gaseous vapours which formed little whirlpools, so to speak, in the molten mass when it was in a sufficiently fluid condition to be acted on in this way.

The paper was illustrated by a number of diagrams and specimens.

At the close the paper was freely criticised by several of the members present who found themselves unable to agree with the theory advanced by the author as the cause of the spheroidal appearance shown by the decomposing gaseous rock.

Mr. PETER MACNAIR, Joint Hon. Secretary, read a paper on "The Intrusive Dolerites of the Glasgow District," in which he noticed the various exposures and their peculiarities and differences from one another. It was illustrated by a large series of microscopic sections of the local dolerites, which had been collected and prepared by the late Mr. Arthur Pratt, who was for many years a working member of the Society.

Digitized by Google

SOCIETY'S ROOMS, 207 BATH STREET, 12TH NOVEMBER, 1903.

Mr. JAMES STEEL, *Vice-President*, in the Chair.

The second meeting of the 46th session of the Geological Society of Glasgow, being the Annual General Business Meeting, was held here this evening.

The HON. SECRETARY (Mr. Murdoch) read the Report of the Council on the work of the past year. The HON. TREASURER (Mr. Hall Wight) read the Annual Financial Statement and the HON. LIBRARIAN (Mr. M'Lennan) read his Report on the work of the Library for 1902-1903.

These Reports were all considered satisfactory, and, after some remarks by members, were unanimously approved.

The following gentlemen were elected as members of the Council:—Messrs. Joseph Sommerville, C. R. Cowie, Robert Dunlop, William Sinclair. The following gentlemen were elected members of the Society:—(1) Mr. William Clarkson, Quarrymaster, 226 West Princes Street, Glasgow; (2) Mr. Thomas B. Dunn, Coalmaster, 21 Bothwell Street; (3) Mr. Mark Hurll, Fire-brick Manufacturer, Redholm, Temple; (4) Mr. W. M. Mackenzie, Teacher (Glasgow Academy), 20 Wilton Gardens; as Associate Member—(5) Mr. Drummond Callander, Student, 39 Rupert Street.

Mr. JAMES NEILSON, Milnbank, exhibited specimens of *Posidonomya punctatella* (Rupert Jones) and *Estheria youngii* (R. Jones) from the shale under the Arden Limestone at Davieland, near Thornliebank, and made an extended series of remarks upon their occurrence and distribution.

Mr. DAVID NIMMO read a paper on "Recent Work in Camp Siluria amongst the Silurian Rocks of Lanarkshire." The paper was illustrated by a number of photographs thrown on the screen by the oxyhydrogen lantern.

SOCIETY'S ROOMS, 207 BATH STREET, 10TH DECEMBER, 1903.

Mr. JAMES STARK, *Vice-President*, in the Chair.

The third meeting of the 46th session of the Geological Society of Glasgow was held here this evening.

The following gentlemen were elected as Ordinary Members:—(1) Mr. Arthur Buchanan, 18 Bute Gardens; (2) Mr. J. Finlay Fleck, 15 Berkeley Terrace; (3) Mr. Quintin Moore, Jun., 219 Greenhead Street; (4) Mr. R. F. Struthers, 22 Crookston Street; and as an Associate Member—(5) Mr. Alexander M'Lean, 466 St. George's Road.

Mr. J. RENWICK read on behalf of Dr. B. N. Peach, F.R.S., F.G.S., an account of a Joint Excursion with the Edinburgh Geological Society which has been made to Arthur's Seat, Edinburgh. The report gave an interesting summary of the various opinions that had been held by eminent geologists as to the structure of this classic section, and upheld certain views originally advanced by Dr. Charles Maclaren, and latterly by Professor Judd.

Digitized by Google

Mr. E. W. GEMMELL exhibited a number of peculiar Crystals which had been dredged from the Clyde near Cardross. These crystals have only been quite recently found in the Clyde, but similar forms have been found in certain localities in England and the Continent. A chemical analysis of the crystals shows that they are principally carbonate of lime and magnesia, with some phosphate of lime and a certain amount of organic colouring matter. The commonest forms may either be considered an acute pyramids or long prisms pointed at both ends, but as they do not present any crystalline faces it is thus difficult to say what their original form may have been. The crystals are evidently pseudomorphs from some other mineral, but what that was has been a matter of considerable discussion. Some authorities refer it to gaylussite, while others consider it to be pseudomorphous after celestite. An animated discussion took place regarding Mr. Gemmell's exhibit, in which Mr. Renwick, Mr. Neilson, and Mr. Macnair took part. For want of time it was found necessary to adjourn the discussion till next meeting.

The SECRETARY then read on behalf of Mr. A. L. Du Toit, B.Sc., F.G.S., of the Geological Survey of South Africa, a revision of a paper read before the Society last year on the "Structure of the Loch Lomond and Aberfoyle Region." The first part of the paper dealt with the marginal belt of black shales and cherts, which the author had named the Kelty series. After giving a minute description of the different rocks composing this group, including their principal petrological and stratigraphical features, the author withdrew his original contention that the Kelty series were separated from the schists of the interior by a distinct unconformity, and arrived at the conclusion that the Kelty Rocks cannot be separated from the great mass of Highland schists, and that they probably represent the lowest members of that formation. The paper was illustrated by a number of slides shown on the screen by the oxyhydrogen lantern.

SOCIETY'S ROOMS, 207 BATH STREET, 14TH JANUARY, 1904.

Mr. CHARLES R. COWIE, *Vice-President*, in the Chair.

The fourth ordinary meeting of the 46th session of the Geological Society of Glasgow was held here this evening.

A claim advanced by the author of a paper on "The Southern Silurian Rocks," read at the November meeting on behalf of Mr. John Steel, being the original discoverer of the fossil fish Thelodus in the strata of Logan Water, Lanarkshire, was withdrawn by him as an erroneous one, and it was agreed, on the motion of Mr. William Clarkson, that the fact should be recorded in the minutes of the Society's Proceedings, that Mr. James Young, of Lesmahagow, was entitled to the honour of the discovery.

Mr. FREDERICK MORT, M.A., B.Sc., F.G.S., Demonstrator in Geology, University of Glasgow, read a paper on "The Structure of Igneous Rocks." [See *Transactions*, vol. xii., p. 290.]

Digitized by Google

SOCIETY'S ROOMS, 207 BATH STREET, 11TH FEBRUARY, 1904.

Mr. JAMES STEELE, *Vice-President*, in the Chair.

The fifth ordinary meeting of the 46th session of the Geological Society of Glasgow was held here this evening.

As duly proposed at the January meeting, the following lady and gentlemen were duly elected members of the Society:—

As Ordinary Members—Mr. Robert Macneil Buchanan, M.B., C.M., F.F.P.S.G, 2 Northbank Terrace, Kelvinside North; Mr. John Gray, 86 Minard Road, Crossmyloof; Mr. Archibald Macintyre, 60 Cadzow Street, Hamilton; Mr. Mathew G. Neilson, Thorncliffe, Cathcart.

As Associate Members—Miss May Ewen, 653 Shields Road, Pollokshields; Mr. A. C. Baird, M.A., Woodburn Avenue, Airdrie; Mr. Hugh Galt, M.B., C.M., &c., 14 Berkeley Terrace; Mr. William M'Pherson, 2 St. John's Villa, Prestwick.

Mr. GEORGE M. CATHCART exhibited specimens of Ruby Sand and Magnetic Sand from Cape Nome, Alaska.

Mr. ROBERT DUNLOP exhibited a number of interesting specimens from New Zealand, including Ruby Sand, Iron Sand, and Gold Sand, Sand-worn Stones, Copper, Iron, and various other minerals, and gave particulars of their occurrence and distribution.

The HON. SECRETARY exhibited, for a member, a series of Photographs of Columnar Structure in the basalts of the Island of Canna and the rock scenery in South Uist.

Mr. JAMES STARK exhibited specimens of Fossil Wood from the volcanic agglomerate of Calciferous Sandstone Age, near Corrie, Arran; and of Honeycombed Sandstone of Triassic Age from the same locality.

Mr. JOHN SMITH read a paper entitled "Notes on the Geology of Wanlockhead and Leadhills," as seen in a recent Excursion of the Society. He first described the massive greywacke rocks exposed near the railway station, in which no bedding-planes are to be seen, but which are so broken up by jointings that it is hardly possible to get pieces large enough for hand specimens. This peculiarity seems to be common to many of the rocks of the district, and probably may account for the universal rounded contours of the hills, rather than the ice action or other denuding agencies to which they have been usually attributed. He next spoke of the anthracite shales, some bands of which are rich in graptolites, those curious organisms which once lived and died on the ocean bed, and which now give a clue to the succession of the strata which contain them. Mr. Smith then described at some length the radiolarian cherts which crop up on the summit of the Sowan Dod Hill, 1784 feet above sea-level. These rocks, which get their distinctive name from the microscopic forms which they contain in myriads, as may be seen on the surface of weathered pieces by the aid of a pocket magnifier, and believed to have been laid down on an ocean bed more than 12,000 feet in depth, as is shown by their recent

Digitized by Google

congeners which are known to be living in the abyssmal depths of the sea bottom at the present day.

Mr. JAMES STARK read a paper on "The Highland Border Fault in the Island of Arran." [See *Transactions*, vol. xii., p. 292.]

SOCIETY'S ROOMS, 207 BATH STREET, 10TH MARCH, 1904.

Dr. R. H. TRAQUAIR, F.R.S., *President*, in the Chair.

The sixth ordinary meeting of the Geological Society of Glasgow was held in the Large Hall here this evening.

Mr. ROBERT DUNLOP gave a lecture upon "New Zealand—the North Island and its Wonderland," in which he brought forward many interesting details of geological phenomena which he had met with in his stay for some years recently in "The Britain of the South." He also brought forward a number of specimens, and a fine series of photographs taken by himself, which were thrown on the screen by the oxyhydrogen lantern.

SOCIETY'S ROOMS, 207 BATH STREET, 14TH APRIL, 1904.

Mr. JAMES STARK, *Vice-President*, in the Chair.

The seventh ordinary meeting of the 46th session of the Geological Society of Glasgow was held here this evening.

Mr. William M'Creath, C.M.E., was elected an Ordinary Member of the Society.

Mr. JOHN SMITH read a paper entitled "Trap Sills"; how they have come off from the sides of dykes, forced asunder adjoining strata, metamorphosed some parts, and cut away others.

In the course of an exhaustive paper on the subject Mr. Smith gave many illustrations of the different phenomena which are to be seen in connection with the intrusion of trap sills and dykes, such as the contact phenomena, in which sandstones have been baked into quartzites and coal into graphite. The macroscopic and microscopic structure and mineral composition of certain of the sills and dykes was also described in some detail, while a number of interesting instances was recorded of the weathering out of large phenocrysts of felspar from their surrounding matrix. The paper was illustrated by a number of rock and mineral specimens, and by a number of drawings on the blackboard.

At the close Mr. Sommerville, Mr. Dunlop, the Chairman (Mr. Stark), and Mr. Macnair made some remarks.

Mr. JAMES NEILSON, Milnbank, read a paper entitled "Notes on Fossiliferous Shales underlying the Arden Limestone at Davieland, near the new Rouken Park, Thornliebank." [See *Transactions*, vol. xii., p. 294.]

Digitized by Google

SOCIETY'S ROOMS, 207 BATH STREET, 5TH MAY, 1904.

Mr. JOSEPH SOMMERVILLE in the Chair.

The eighth ordinary meeting of the 46th session of the Geological Society of Glasgow was held here this evening.

Mr. James Rutherford was elected an Ordinary Member.

Mr. PETER MACNAIR, Hon. Secretary, exhibited a simple form of Reflecting Goniometer, and explained its construction and use.

Mr. GOODCHILD, of the Geological Survey, gave an address on "The Modes of Occurrence and Origins of Intrusive Rocks." [See *Transactions*, vol. xii., p. 305.]

SOCIETY'S ROOMS, 207 BATH STREET, 2ND JUNE, 1904.

Dr. TRAQUAIR, F.R.S., *President*, in the Chair.

The ninth and last meeting of the 46th session of the Geological Society of Glasgow was held here this evening.

Mr. ROBERT DUNLOP exhibited, with remarks, a Scottish specimen of *Fenestella*, showing *Palæcoryne* or some other polyzoal appendages described by Professor John Young and Dr. John Young in 1874.

On this Mr. Macnair also made a few remarks.

Mr. DUNLOP also exhibited a number of specimens from New Zealand, illustrating the Stone Age there, and described them at some length.

Mr. JOHN SMITH exhibited, with remarks, specimens from the Upper Coal-Measure strata of the Craigmarle Glen, Dalmellington, Ayrshire, showing the presence of *Productus* and other marine fossils, including plant remains. He stated that *Lingula mytiloides* occurs at Lugar and near Annbank, in Ayrshire, as he had previously stated, but the present is, so far as he knew, the first recorded occurrence of *Productus*, &c., in the Ayrshire Upper Coal-Measures.

They have, however, been recorded in our *Transactions* as found in the strata near Coatbridge and Calderbank, and also in the East of Scotland.

Mr. SMITH also exhibited, with remarks, a series of specimens from the Trap Sills of Ayrshire, in further illustration of his paper on the subject, read at a previous meeting.

Mr. JOHN SMITH read a paper on "Crystallised Carbonite," a mineral new to Scottish rocks. [See *Transactions*, vol. xii., p. 308.]

Mr. MATHEW BLAIR read a paper entitled "Some Difficulties of a Young Geologist."

Amongst such troublesome points might be mentioned:—Denudation, Contortion, Faulting, and Metamorphism, and these the author dealt with from the point of view of the amateur, and gave his definition and solution of them to some extent. Denudation was shown to be the most powerful agent in sculpturing out the contour of our land surfaces. Contortion indicated crushing caused by pressure from constant contraction of the

Digitized by Google

earth's crust, being thus greatest in the oldest rocks. Faulting of rock masses was shown to be of great value to us industrially, as it had made available for use products which otherwise would have lain too deep to be reached for practical purposes. Metamorphism was still a puzzle which he did not feel able to explain.

PROCEEDINGS FOR SESSION 1904-1905.

(47TH SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET, 20TH OCTOBER, 1904.

Dr. R. H. TRAQUAIR, F.R.S., *Vice-President*, in the Chair.

The first ordinary meeting of the 47th session of the Geological Society of Glasgow was held here this evening.

Mr. William Jolly, F.G.S., having been previously proposed by the Council, was unanimously elected an Honorary Member of the Society.

Mr. JAMES STARK then took the Chair, and Dr. TRAQUAIR gave a lantern demonstration on the "Fish-fauna of the Upper Old Red Sandstone." At the outset he gave a description of the geological structure of the Upper Old Red Sandstone area of the Moray Firth, and then passed to a consideration of the general classification of the Old Red Sandstone Rocks of Scotland.

He pointed out that, about two years ago, a reversion had finally been made to the classification of these rocks propounded many years ago by Sir R. Murchison, namely, Lower, Middle, and Upper Old Red Sandstone. For many years, and in entire disregard of the most striking palæontological evidence, the Orcadian and Caledonian Rocks had been referred to the same period in time, but it was now clearly shown that they belonged to two distinct periods, of which the Orcadian was the younger and the Caledonian the older. Dr. Traquair then passed on to review the different fish forms found in the Upper Old Red Sandstone of the Moray Firth, including the different species of the following genera:—*Asterolepis*, *Holoptychius*, *Polyplocodus*, *Coccosteus*, *Psammosteus*, *Bothriolepis*, and *Phyllolepis*. The distribution and zonal values of these fish remains were also discussed in some detail.

Dr. B. N. Peach, F.R.S., spoke regarding the relationships of the Upper Old Red and Carboniferous Rocks south of the Grampians, and referred to the finding of *Holoptychius* scales in the cornstones of the Salisbury Crag,

Digitized by Google

which seemed to show that certain beds which had hitherto been regarded as Carboniferous belonged to the Old Red Sandstone period.

Mr. MACNAIR, Joint Hon. Sec., referred to the great discrepancy between the flora of the Orcadian and Caledonian Old Red Sandstones, while Mr. Blair spoke on the bearing of Dr. Traquair's researches upon the theory of evolution.

Dr. TRAQUAIR also read a short paper on "Some New Carboniferous Fish Remains," in which he described two selachian spines found in the West of Scotland, and both new to science, to which he had given the names *Bertacanthus tuberculatus* and *Bertacanthus striatus.*

SOCIETY'S ROOMS, 207 BATH STREET, 10TH NOVEMBER, 1904.

Mr. JAMES STEEL, *Vice-President*, in the Chair.

The second meeting of the 47th session of the Geological Society of Glasgow, being the Annual General Business Meeting, was held here this evening.

The Report of the Council for the past year, 1903-1904, was read. This stated that the progress of the Society had been satisfactory, but that still there was considerable room for its development. They believed that with the foundation of the new Chair of Geology in the University, and the appointment of Dr. J. W. Gregory to it as its first Professor, a considerable impetus would be given to the study of Geology in the West of Scotland, and thus materially advance the interests of the Society.

Mr. E. HALL WIGHT, Hon. Treasurer, submitted his Financial Statement for 1903-1904, which showed a satisfactory condition of the funds, and Mr. J. S. M'LENNAN, Hon. Librarian, gave his Annual Statement on the work of the Library during the year, 1903-1904.

The following gentlemen were declared duly elected for three years:—as Vice-President, Mr. David Chalmers; as Members of Council, Dr. B. N. Peach, F.R.S., Mr. John Renwick, Prof. A. H. Sexton, and Mr. James Stark.

The following gentlemen were elected Ordinary Members of the Society:—(1) Mr. John Walker Gregory, D.Sc., F.R.S., Professor of Geology in the University of Glasgow; (2) Mr. Leslie Thomas, 280 George Street, Glasgow.

The following gentlemen were elected Associate Members:—(1) Mr. Robert Knox Paton, 17 Stanmore Road, Mount Florida, S.S.; (2) Mr. Charles R. Neilson, Thorncliffe, Cathcart; (3) Mr. Isaac Wannop Lamonby, Royal Bank House, Lesmahagow; (4) Mr. James Drylie, 5 George Street, Barrhead; (5) Mr. Alexander M'Lean, 466 St. George's Road; (6) Mr. George B. Elliot, 33 Millbrae Road, Langside; (7) Mr. James A. Booth, 4 Roxburgh Street, Glasgow; (8) Mr. John Mowbray, 23 Edmund Street, Dennistoun; (9) Mr. G. Brown, c/o M'Lellan, 330 Crown Street.

Digitized by Google

Mr. JOSEPH SOMMERVILLE exhibited a number of specimens of Sulphide of Mercury (cinnabar) from Mount Avala, Servia, and made some remarks upon the crystalline forms shown in the specimens, their composition and mode of occurrence.

Mr. MACNAIR exhibited specimens of Bothriolepis from the Upper Old Red Sandstones of the Heads of Ayr, and a number of plant and fish remains from the cement stone division of the Calciferous Sandstones of the same locality, regarding which he made some remarks.

Dr. Peach referred to the extreme paucity of organic remains from these deposits, and advocated a careful search for specimens which would throw any light upon the fauna and flora of this particular division of the Carboniferous Rocks.

Mr. CHARLES R. COWIE, Vice-President, read a paper entitled "Notes on the Intrusive Dykes at Lochranza, Arran," in which, after referring to the well-known dykes of dolerite of the normal type, he proceeded to describe certain vein or dyke-like masses, evidently occurring in fault fissures, and consisting in one case of pure quartz, and in the other of fragments of Highland schist, and other country rocks set in a fine matrix of argillaceous material. In offering some suggestions as to the manner in which these dykes had been formed, he thought that, in the case of the dyke or vein of quartz, the passage of superheated water charged with silica in solution through the fissure might possibly explain the phenomena which he had described, while, in the case of the dyke filled with fragments of the country rock, he suggested that it was probably of the nature of a fault fissure filled with fault breccia.

Professor J. W. Gregory, F.R.S., said that a case had come under his notice in which an intrusive dyke of ultrabasic material had been almost entirely replaced by pure silica.

Mr. COWIE also read a paper entitled "Additional Remarks and Observations on the Moraine at Caticol, Arran," in which he brought forward further evidence in support of the position he had taken up in the paper previously contributed to the Society—namely, that the ridge of debris seen near the shore is a true lateral moraine, and not a marine deposit, as had been advocated by the Officers of the Survey. An animated discussion took place upon the various points advanced by Mr. Cowie.

SOCIETY'S ROOMS, 207 BATH STREET, 8TH DECEMBER, 1904.

Mr. CHARLES R. COWIE, *Vice-President*, in the Chair.

The third meeting of the 47th year of the Geological Society of Glasgow was held here this evening.

Mr. GOODCHILD, F.G.S., of H.M. Geological Survey and Keeper of the Mineralogical Collection in the Royal Scottish Museum, Edinburgh, delivered an interesting address entitled "A Geologist's Ideas on Lithology." In the course of it he laid before the members a revised classification of

Digitized by Google

eruptive rocks, chiefly, as he explained, with the object of simplifying their nomenclature, which has gradually, in the course of a number of years, drifted into a state of confusion. He pointed out that the really essential features in any scheme of classification of eruptive rocks would be, first, their chemical composition; second, the condition under which they have primarily consolidated; third, the characteristics due to absorption of material during the early stages of their formation; and fourth, the effects arising from changes by which they have been affected subsequent to their first consolidation. He then passed on to give an outline of a classification based upon these characteristics, which would be applied without any difficulty, not only to any of the eruptive rocks, but also to their corresponding aplites, pegmatites, and gneisses.

The paper was illustrated by a series of diagrams and sections of eruptive rocks thrown on the screen by the oxyhydrogen lantern. At its close some remarks were made by Professor J. W. Gregory, F.R.S., who stated that he had listened with great interest to the lecturer's remarks, and that he was mainly in accord with the views he had expressed. After a hearty vote of thanks to Mr. Goodchild, the Society adjourned to the evening of 12th January next.

SOCIETY'S ROOMS, 207 BATH STREET, 12TH JANUARY, 1905.

Mr. DAVID CHALMERS, *Vice-President*, in the Chair.

The fourth meeting of the 47th session was held here this evening.

Mr. MATHEW BLAIR spoke of the complimentary dinner which had been given to Dr. J. W. Gregory, Professor of Geology in the University of Glasgow, by the Society on 15th December last, and hoped that some record of it would be placed in the Proceedings of the Society as an event of interest and importance in its annals. He begged to move to that effect, and the motion, being seconded by Mr. James Neilson, was unanimously approved.

Mr. JOHN SMITH exhibited specimens of Palæoxyris from Greenhill, Kilmaurs, Ayrshire, and stated that this curious fossil form had been described so long ago as 1828 by Brongniart, who thought it was "a spindle-shaped flower with both stamens and pistils," and gave it the name above-mentioned because he thought it had a resemblance to the recent Zyris. His specimens came from the variegated sandstone of the Lower Trias.

In 1840 Morris described a specimen from the Coal-measures of Coalbrookdale, in Shropshire, but placed it in the genus Carpolettes. Since that date the organism has been variously called a "mysterious plant," a "seed vessel," and a "shark's egg." At Greenhill it is associated with a peculiar fauna and flora, and as there is a total absence of brachiopods and fish remains, such as are usually found in marine strata, it may be inferred that the beds there are of fresh-water origin.

Digitized by Google

Mr. SMITH also exhibited a variety of Amygdules of Pectolite from Castle Hill, Dalry, Ayrshire, where it occurs both massive and in radiating bundles of narrow crystals—white, pink, or pale green in colour, in gas cavities of the amygdaloidal dolerite rock. It is also found at Lendalfoot, and at Kilsyth in veins; but the present is the only locality in which it has been got in gas cavities in the rock. The quarry at Castle Hill has only lately been opened in connection with the new Paisley water works, so that specimens of the mineral will only be obtainable from it for a short period.

Mr. FREDERICK MORT, M.A., B.Sc., F.G.S., Demonstrator in Geology in the University of Glasgow, read a paper on "The Crystallisation of Rocks." [See *Transactions*, vol. xii., p. 311.]

Mr. PETER MACNAIR, Joint Hon. Sec., read a paper entitled "Notes on the Discovery of an Outlier of the Loch Tay Limestone on Beinn Bhreac, Loch Tay, Perthshire." [See *Transactions*, vol. xii., p. 318.]

SOCIETY'S ROOMS, 207 BATH STREET, 9TH FEBRUARY, 1905.

Mr. JAMES STEEL, *Vice-President*, in the Chair.

The fifth meeting of the 47th session of the Geological Society of Glasgow was held here this evening.

Mr. JOSEPH SOMMERVILLE exhibited specimens of Chalcedony Geodes holding water, and made some remarks upon their formation.

The specimens shown came from Uruguay, Brazil, and Lake Superior.

Mr. JOHN SMITH exhibited under the Society's microscope specimens of minute Crystals of Iron in furnace slag from New Cumnock, and also hand specimens of Slag with large crystals, and made some remarks upon their occurrence.

Mr. JAMES ANDERSON read a paper entitled "Notes upon Transvaal Geology in its bearing on the Premier Diamond Mine."

In the course of his remarks the author said that the wonderful amount of wealth now being produced in South Africa ensures our attention to anything said or written on the subject that is calculated to throw fresh light upon the geological features of that country.

Dr. Gregory, in making some remarks, said he had personally examined the "blue ground" at Kimberley, and had no doubt that it must have been on the line of an old volcanic vent, from the extreme basic nature of the material. He complimented the author on his suggestive paper.

Mr. J. B. MURDOCH, Hon. Sec., gave a *résumé* of the recent correspondence in the London *Times* on the subject of water-finding as connected with the use of the divining rod or "dowser," and afterwards summarised his own recollections and experiences regarding its use locally.

Dr. Gregory, who had been one of the *Times*' correspondents, said he was inclined to believe there was something in the sensitiveness of certain

Digitized by Google

individuals to the passage of underground water—it might be phrased as "nervous irritation."

Mr. Alexander Munro said that his actual experiences at Clydebank were dead against the assumed pretensions of the so-called water-finder. His firm had been led astray in boring there to the extent of hundreds of pounds.

SOCIETY'S ROOMS, 207 BATH STREET, 9TH MARCH, 1905.

Mr. DAVID CHALMERS, *Vice-President*, in the Chair.

The sixth meeting of the 47th session of the Geological Society of Glasgow was held here this evening.

Mr. John Paisley, 25 Gordon Street, was elected an Ordinary Member.

A photograph of an excursion of the Society to Rumbling Bridge in 1903, and containing portraits of Dr. Peach and other members, was presented to the Photographic Album by Mr. Laird, who had taken it, and he was thanked for the gift.

Mr. JAMES STARK exhibited specimens of Precipitates from mineral solutions, including Stalactites from New Zealand, Gibraltar, and Great Cumbrae, and Geyserite from North Berwick.

Regarding the last-named, he stated that it had been deposited in layers laid down in succession round the orifices of geysers or hot springs, whose waters contained various mineral silicates in solution like those of New Zealand and Iceland amongst others of the present day.

Mr. STARK also exhibited "Landscape Marble" from North Africa and from Bristol, a calcite formed in cavities of the limestone rock through the infiltration of water containing carbonate of lime, often coloured with oxide of iron and manganese. From irregular deposition the layers of calcite were often pierced by cross-deposits, and, owing to this, cut and polished sections simulated the appearance of drawings or mosaics of buildings, landscapes, &c., and were hence known as "Landscape Marble."

Mr. JOHN SMITH read an interesting paper on "The Gareland Cleuch," a remarkable ravine situated at a high level in the moorlands of Dumfriesshire between Mount Stuart and Knockenshag and Kirklea Hills. It is nearly five miles due east from Kirkconnel, and the "hass" (*i.e.*, throat) of the "Cleuch," is within half a mile of the old Strathavon and Sanquhar road, the Dumfriesshire part of which is still kept in good repair, but the Ayrshire portion has been allowed to go to wreck and ruin. For this reason any one wishing to visit "The Gareland Cleuch" should drive from Sanquhar Station by this old road, which would bring them to within half a mile of its upper end.

Or the ravine can be reached from Kirkconnel *via* Glenaylmer, a long, straight glen, which has been cut through the Silurian strata. The rock in which this curious gorge has been excavated is probably an agglomerate of Old Red Sandstone age, which has doubtful lines of stratification dipping south-west.

Digitized by Google

Its rocky walls are in places not less than 150 feet high, and these vertically sometimes as much as 100 feet.

Its whole appearance and the evidence of the surrounding slopes and ridges strongly suggest that they have been formed by the action of sea waves and currents.

Mr. James Stark, Mr. A. A. Young, and Mr. J. Anderson made some remarks on Mr. Smith's paper.

Mr. JAMES S. M'LENNAN, Hon. Librarian, read a paper entitled "Notes on the Basin of the Annick Water, Ayrshire."

In the course of his paper the author described the surface features of the neighbourhood, with its houses, villages, and towns, and other matters of interest. He also spoke of the underlying rocks as worked industrially at the various pits and quarries—coal, ironstone, limestone, &c.

SOCIETY'S ROOMS, 207 BATH STREET, 13TH APRIL, 1905.

Mr. JAMES STEEL, *Vice-President*, in the Chair.

The seventh ordinary meeting of the 47th session was held on Thursday evening, 13th April, in the Society's Rooms, 207 Bath Street, Mr. James Steel, Vice-President, in the Chair.

Mr. John Adams, Tannoch Place, Milngavie, and Mr. H. H. Roderick, C.E., 4 West George Street, were elected Ordinary Members.

The paper announced for the evening, "The Parallel Roads of Lochaber, with Relation to an Ice Cap" (a new theory), by Mr. COLIN LIVINGSTON, Hon. Member, Fort-William, was, in consequence of the author's absence from illness, read by Mr. MATHEW BLAIR. [See *Transactions*, vol. xii., p. 326.]

SOCIETY'S ROOMS, 207 BATH STREET, 4TH MAY, 1905.

Mr. DAVID CHALMERS, *Vice-President*, in the Chair.

The eighth meeting of the 47th session of the Geological Society of Glasgow was held here this evening, Mr. David Chalmers, Vice-President, in the Chair.

Mr. William P. R. Parker, Strathmuir, Kilmacolm, was elected an Ordinary Member, and Mr. James Chisholm, Renton, an Associate Member of the Society.

The whole time of the meeting was taken up with the discussion of a paper on "The Parallel Roads of Lochaber, with Relation to an Ice Cap," by Mr. COLIN LIVINGSTON, Northcombe, Fort-William, which had been read at the April meeting, but at which the author had unfortunately been prevented from being present in person, owing to illness.

Mr. Livingston gave a *résumé* of his theory, objecting to the usually accepted one as to the formation of the "Roads," that they were formed along the margin of a lake ponded back by a glacier which descended Glen

Digitized by Google

Spean, and that they really had been formed along trenches which he believed had existed between the glacier and the over-topping hillside.

In the subsequent discussion, Mr. James Neilson pointed out that in the Himalayas there are several instances where glaciers descend from side valleys, and crossing the main valley convert a portion of it into a lake by damming up the river flowing down it.

If, on the other hand, the "Roads" had been formed on Mr. Livingston's theory in trenches running along each side of the glacier, they would naturally follow the same inclined plane as the ice and the trenches, and therefore would not be approximately level, as they admittedly are.

Mr. William Jolly and various other members also took part in the discussion, generally not agreeing with the author of the paper in his Ice Cap theory.

Professor Gregory, in the course of his remarks, suggested that an Excursion of the Society might be arranged for the coming autumn to go over the district of the Parallel Roads.

SOCIETY'S ROOMS, 207 BATH STREET, 27TH MAY, 1905.

Mr. C. R. COWIE, *Vice-President*, in the Chair.

The ninth and last meeting of the 47th session of the Geological Society of Glasgow was held here this evening, Mr. C. R. Cowie, V.-P., in the Chair when the minutes of the previous meeting were read and approved.

Mr. William Jack, Houston, Renfrewshire; Mr. Bennet Dobson, 388 Great Western Road, and Mr. James Begg, Elms, Mount Vernon, were elected Ordinary Members.

Dr. J. W. GREGORY, F.G.S., F.R.S., Professor of Geology in the Glasgow University, moved the following resolution:—"That this meeting of the Geological Society of Glasgow respectfully urges upon the Secretary for the Board of Education the desirability of colour-printing the one-inch maps of the Geological Survey of Scotland, which deal with coal-fields and other areas of special economic or geological importance. It believes that the extension of the system of colour-printing, already adopted by the Board of Agriculture for the English maps, would lead to the greatly increased usefulness of the work of the Scottish Geological Survey." Mr. Cowie moved that the word "urgent" be placed before desirability, and this Professor Gregory agreed to.

Hereafter, Mr. J. Renwick seconded the motion, which was unanimously approved of by the members, and the secretaries were instructed to send a copy of the resolution to the Secretary for the Board of Education.

Mr. R. S. HOUSTON read a paper entitled "Notes on some New and Rare Minerals from Renfrewshire." [See *Transactions*, vol. xii., p. 354.]

Mr. PETER MACNAIR, Joint Hon. Sec., read a paper on "The Geology of the Rouken Glen and its Neighbourhood." [See *Transactions*, vol. xii., p. 362.]

Digitized by Google

EXCURSIONS FOR THE SEASON OF 1903.

To Geological Gallery, Kelvingrove Museum — Mr. P. Macnair, conductor—on Saturdays, 17th January, 14th February, and 14th March.

To Arkleston Railway Cutting, near Paisley, Renfrewshire — Mr. Mathew Blair, conductor—on Saturday, 28th March.

To Ardrossan Waterworks Extension, Ayrshire—Mr. John Smith, conductor—on Saturday, 11th April.

To Devon Valley, Kinross- and Perthshires—Dr. B. N. Peach, F.R.S., conductor—on Monday, 13th April (Glasgow Spring Holiday).

To Corrieburn, Stirlingshire—Mr. James Anderson, conductor—on Saturday, 25th April.

To Glorat, Campsie, Stirlingshire—Mr. James Anderson, conductor—on Saturday, 9th May.

To St. Andrews, Fifeshire—Mr. Goodchild, F.G.S., H.M. Geol. Survey, conductor—on Thursday, 21st May (Victoria Day).

To Arden, Loch Lomond, Dumbartonshire—Mr. James Lumsden of Arden, conductor—on Saturday, 6th June.

To Ben Lomond, Stirlingshire—Mr. Peter Macnair. Hon. Sec., conductor—on Saturday, 20th June,

To Wanlockhead, Dumfriesshire, and Leadhills, Lanarkshire—Mr. John Smith, conductor—on Saturday, 8th August.

To Devol's Glen, Port-Glasgow, Renfrewshire—Mr. Joseph Sommerville, conductor—on Saturday, 22nd August.

To Arthur's Seat, Edinburgh (Joint Excursion with Edinburgh Geol. Socy.)—Dr. B. N. Peach, F.R.S., conductor—on Saturday, 15th October.

EXCURSIONS FOR THE SEASON OF 1904.

To the Hunterian Museum, University of Glasgow—Mr. F. Mort, M.A., B.Sc., F.G.S., conductor—on Saturday, 12th March. The party met under the College Tower, Main Door, at 3 p.m., and proceeded to examine a number of the more interesting geological and mineralogical collections in the Museum.

To Aberlady, East Lothian (a Joint Excursion with Edinburgh Geological Society)—Dr. C. B. Crampton, of H.M. Geol. Survey, conductor—on Saturday, 26th March. The Glasgow party left Waverley at 1-45 p.m. for Longniddry Station. Here, leaving the train, they visited the Harelaw Limestone Quarries in the Lower Limestone formation, which are very fossiliferous. They then traversed the coast section of the same series, from Dalskelly Crags to Aberlady, there being low water on the shore at 5 p.m. The distance walked was fully six miles.

To North Queensferry (the new Naval Base and Charlestown)—Mr. Goodchild, F.G.S., H.M. Geological Survey, conductor—Monday, 4th

Digitized by Google

April (Glasgow Spring Holiday). The party left Queen Street Station (N.B. Ry., High Level) at 9 a.m. for North Queensferry. The stratified rocks are of Lower Carboniferous age, and belong to the upper half of the Oil Shale series. They are of marine and estuarine origin. The equivalent of the Hurlet limestone has been formerly much quarried near Charlestown. At North Queensferry there is a thick sill of dolerite which has been long worked, and is well seen in the large quarries, as also in the many good natural exposures. Deep grooves have been carved in the face of the rocks by land-ice during the Age of Snow, and these furrows have been subsequently modified during the formation of the Raised-beaches. The bed of the Forth is very uneven at this part, and some remarkable "deeps" are cut out of it near North Queensferry. The distance walked was about eight miles.

To Port Seton, East Lothian (a Joint Excursion with Edinburgh Geological Society)—Mr. E. B. Bailey, B.A., and Mr. D. Tait, of H.M. Geological Survey, conductors—on Saturday, 9th April. The party left Queen Street (N.B. Ry., High Level) Station at 12-27 p.m., taking Saturday return tickets to Prestonpans. On reaching Port Seton a small basin of the true Coal-measures, recently discovered during the revision of the district by the Geological Survey, was inspected, and its plant-beds, two thick coal-seams, and mussel-bed, were examined. The party then walked eastward along the coast over a complete section of the Millstone Grit and the Upper Limestone series. The former is of particular interest as having yielded marine fossils on two horizons about its middle part; and also from its plant-beds, which have helped Mr. Kidston to determine the position of the palæo-botanical break between the Upper and Lower Carboniferous rocks. The section is traversed by two dolerite dykes. The distance walked was about five miles.

To Watermeetings, Annick Water, Ayrshire—Mr. John Smith, Monkredding, conductor—on Saturday, 23rd April. The party left St. Enoch Station at 1-20 p.m. for Cunninghamhead Station. On arrival the party took the Stewarton Road, turning left towards Watermeetings, where on both sides of Annick Water there is a large Dolerite Sheet, of plated structure. It is well seen in the West Quarry, the "plates" being arranged in the form of a syncline. This trap lies somewhere between the Coal-measures and the Upper Limestone series. In the same quarry there is a large transported block of Highland rock. The total walk was about four miles.

To Millport, Cumbrae—Mr. James Steel, V.P., conductor—on Saturday, 7th May. The party left St. Enoch Station for Fairlie Pier at 1-15 p.m. for Millport, and thence by steamer to Millport. The line of fault which crosses Great Cumbrae almost follows the outline of the eastern boundary of Millport Bay, the downthrow caused by it being about 1000 feet. It appears to have taken place before most of the intrusions of the igneous rocks which affect the strata of both the Old Red and the Lower Carboniferous formations. Besides the abundant red

Digitized by Google

sandstone rocks there are white sandstones and red clays or shales, also conglomerates of Old Red age. Passing westward, the shore road runs along the top of an old Raised-beach, and in the West Bay there is a considerable thickness of red clays, with frequent thin sandstone layers. There are many dolerite dykes, which run in various directions. Near the Battery Point the old line of sea-cliffs, finely water-worn, is still to be found in good preservation. The distance walked was about four miles.

To Dalmellington, Ayrshire—Mr. John Smith, Monkredding, conductor—on Monday, 23rd May (Victoria Day). The party left St. Enoch Station at 9-30 a.m. for Dalmellington. The party took the New Cumnock Road, and ascended Benbeoch Hill (over 1500 feet), with the object of examining the great inland cliff of dolerite which forms the eastern end of the upper part of the hill. This trap lies near the upper part of the Coal-measures, a short way above the Craigmark Ironstone, and is probably the remnant of a large sill. Heavy falls of rock have evidently occurred from it in former times, and large blocks strew the ground for about half a mile. The question as to the denudation was discussed, the conductor giving his views. Many large granite boulders strew the surface near Dalmellington, and extend towards Ochiltree and the Ayrshire coast. Marine shells of Arctic type are found in the drift beds here.

To Ballagan, Stirlingshire (a Joint Excursion with Edinburgh Geological Society)—Mr. Joseph Sommerville, conductor—on Saturday, 4th June. The party left Queen Street Station at 2-30 p.m. for Strathblane. The chief object of this excursion was the cliff section in the glen, belonging to the Lower division of the Carboniferous rocks, known as the "Ballagan Beds." These consist of a series of thin-bedded deposits, containing "upwards of 230 beds of limestone, sandstone, and marly shales, seen to lie, tier upon tier, in a slightly inclined position, and capped by massive beds of whitish sandstones and traps" ("Campsie," by the late Dr. John Young, F.G.S., *Transactions*, vol. i.). None of the limestone beds are above one foot thick; they are nodular and dolomitic, containing about 17 per cent. of magnesia. There are varieties of gypsum here—one impure, massive, reddish; another pure, white, fibrous; and a third yellowish, fibrous. Further up-stream a broad basalt dyke, probably Miocene, runs east and west, with semi-circular sheets of two to four inches. In the centre of the Blane Valley, a conspicuous object is Dunglass, a conical hill of basalt, with fine columnar structure. The distance walked was about three miles.

To The Heads of Ayr, Ayrshire (a Joint Excursion with the Natural History Society of Glasgow)—Mr. James Stark, V.P., conductor—on Saturday, 25th June. The party left St. Enoch Station at 1 p.m. for Ayr. They then proceeded per tram-car to Burns' Monument, Brig of Doon, and walked from that point. The cement-stone division of the Calciferous Sandstones is well developed along the shore from the Doon

Digitized by Google

to "The Heads of Ayr," and is traversed by many dolerite dykes of Tertiary age, one showing fine spherulitic structure. At Greenan and the "Heads" masses of felspathic tuffs, interstratified with, and intruding through, the cement stones, are probably the remains of a volcanic vent of Upper Calciferous age. In places they are weathered into fantastic forms. Beyond these, in red felspathic sandstones on the beach, according to Sir A. Geikie, remains of *Pterichthys* have been found. On these are the uppermost members of a grand series of lava-flows of Old Red age, with occasional beds of sandstone interstratified, which form the bulk of the Carrick Hills, and extend along the coast almost as far as Girvan. Like the Ochil andesites, probably contemporaneous, these lavas are highly amygdaloidal, and agates, etc., are not uncommon in them. A short distance past "The Heads of Ayr," appears a fine section of the Lower or Red Sandstone division of the Calciferous Sandstone series, faulted down among the Old Red andesites, and forming a fine range of sea-cliffs. The distance walked was about five miles.

To Loch Loskin, Kirn, Argyllshire—Mr. Peter Macnair, Joint Hon. Sec., conductor—on Saturday, 6th August. The party left St. Enoch Station for Princes Pier at 1-58 p.m., and per steamer for Kirn. The schists here belong to the Lower Argillaceous zone of the Highland Metamorphic series, being so classed because of the predominance of their finer argillaceous materials, shown by the buff, grey, and purple phyllites. Limestones and occasional beds of grits and greywackes also occur, showing a series of isoclinal folds crossed by foliation planes dipping south-east about 53 degrees. On Hafton Hill a sill of epidiorite has invaded the sedimentary schists before their metamorphism, and has also suffered with them. Under the microscope this rock has all the appearance of a typical hornblende schist, being composed of alternate foliæ of felspar and hornblende. In the quarry face, on the hill-top there is a rough foliation dipping towards the south-east. In the low ground, between Hafton Hill and Dunloskin, lies Loch Loskin, probably a lake-basin excavated out of the schists, the barrier at its outlet being formed by the above-mentioned epidiorite sill. The distance walked was about four miles.

To Ardlui, Dumbartonshire—Mr. James Anderson, conductor — on Saturday, 27th August (Trades' Holiday). The party left Queen Street Station at 8-32 a.m. for Ardlui. The metamorphic rocks near Ardlui belong to the Lower Arenaceous zone, which further south forms such important mountain masses as Ben Lomond, Ben Venue, and Ben Ledi. In the latter district the original clastic structure of these schists is evident, as frequently the grits and greywackes are composed of large pebbles of quartz and felspar. Upon tracing these beds towards the north-west in the direction of Loch Lomond they will be seen to have undergone more intense metamorphism, passing into albite, gneisses, and mica schists. The "green beds" lying immediately above the Ben Ledi grits, and which are also clearly of clastic origin, have, like them, been intensely

Digitized by Google

metamorphosed, and in the railway section north of, and close to, Ardlui Station, they pass into hornblende schists, not distinguishable, in hand specimens, from those of igneous origin. At the head of Loch Lomond there are some interesting phenomena connected with the advance of the delta of the Falloch, and the gradual silting up of the loch, the Geal Loch having been here cut off from the parent sheet of water. The distance walked was about six miles.

To Logan Water, Lanarkshire—Mr. David Nimmo, Jun., conductor—Monday, 26th September (Autumn Holiday). The party left Central Station by train for Lesmahagow at 8-57 a.m. This excursion gave an opportunity of examining the lithological characters and general structure of the Lesmahagow Upper Silurian inlier. The rocks here have been folded into a dome-shaped anticline, with the oldest (the Wenlock) in the centre, and passing upwards through the Ludlow and Downtonian formations into the basement beds of the Old Red Sandstone, into which, according to the officers of the Survey, they merge without a break. A large fault, which brings the underlying Ludlow beds against the higher Silurian rocks, crosses this anticline. During the course of the day the party visited some of the principal fossiliferous horizons and localities, where there were opportunities of collecting specimens of the rich and varied rock-fauna of the district. Numerous intrusions of igneous rocks, principally sills and bosses of pale pink felsite, and basalt dykes of Miocene age were also examined.

To Arthur's Seat, Edinburgh (a Joint Excursion with Edinburgh Geological Society)—Dr. B. N. Peach, F.R.S., H.M. Geological Survey, conductor—on Saturday, 15th October. The party left Queen Street Station at 1 p.m. for Edinburgh. On arrival at Waverley Station they proceeded to Holyrood, and joined the Edinburgh party in front of the palace. The object of this excursion was to show the members the relationship of the rocks of Dunsappie and Duddingstone to those of the Whinney Hill and the older part of the volcano.

Evening Excursions in 1904.

To Giffnock, Renfrewshire—Mr. Peter Macnair, Joint Hon. Secretary, conductor—on Thursday, 28th April. Train from Central Station to Giffnock at 6-15 p.m. Carboniferous Sandstones, and shales containing numerous plant remains.

To the New Dock, Clydebank, Dumbartonshire—Mr. Joseph Sommerville, conductor—on Tuesday, 19th May. The party met at tramway terminus at Clydebank at 6-15 p.m., taking tram-car from city. Exposures of Post-Tertiary deposits and boulder-clay.

To Tollcross, Lanarkshire—Mr. John Main, F.G.S., conductor—on Thursday, 9th June. The party met at Tollcross tramway terminus at 6-30 p.m., taking tram-car from city. Shales with abundance of plant life, and very fine Post-Tertiary deposits.

Digitized by Google

THE GEOLOGICAL SOCIETY OF GLASGOW.

ABSTRACT of the TREASURER'S ACCOUNTS for the Year ending 30th September, 1903.

CASH ACCOUNT.

RECEIPTS.

To Cash in Bank on Deposit,	£115 0 0	
,, Cash in Treasurer's hands,	5 1 10	
		£120 1 10
,, Subscriptions for current year and Arrears,		81 5 0
,, New Members,		9 0 0
,, Life Member,		5 5 0
,, Associate Members		0 15 0
,, Interest on Funds,		7 9 11
		£223 16 9

EXPENDITURE.

By Reprints from Volume XII., Part 2, of *Transactions*—Mr. Goodchild's and Mr. Anderson's Papers and Illustrating,	£2 6 4	
,, Illustrating Supplement to Volume XII., Part 1,	3 17 10	
,, ,, Volume XII., Part 2,	3 18 0	
		£10 2 2
,, New Books, Maps, and Magazines,		10 15 10
,, Subscription to Millport Marine Station,	£1 1 0	
,, Subscription to Palæontographical Society,	1 1 0	
		2 2 0
,, Rent, Insurance, and Attendance,	£14 15 0	
,, Printing and Postage of Circulars, &c.,	16 17 7	
,, Advertising,	6 11 6	
,, Lantern and Lecture Expenses,	2 8 0	
,, Collector's Commission,	2 17 0	
,, Disbursements by Hon. Secretaries, Postages, Stationery, and Petty Expenses,	7 2 0	
		50 11 1
,, Cash in Bank on Deposit,	£145 0 0	
,, Cash in Treasurer's hands,	5 5 8	
		150 5 8
		£223 16 9

STOCK ACCOUNT.

To Life Subscription Account,		£246 15 0
,, Capital Account,*		573 10 8
		£820 5 8

* NOTE.—Subject to cost of Publishing *Transactions*.

By Campbeltown Corporation Loan,	£170 0 0	
,, Cash in Bank and on hand,	150 5 8	
		£320 5 8
,, Property—		
Books in the Library,	£440 0 0	
Furniture, Bookcases, and Microscope,	60 0 0	
		500 0 0
		£820 5 8

GLASGOW, 23*rd October*, 1903.—Examined, compared with relative Vouchers and Securities, and found correct, the balance in Treasurer's hands being Five Pounds Five Shillings and Eightpence.

JOSEPH SOMMERVILLE,
CHAS. R. COWIE, } *Auditors.*

Digitized by Google

ABSTRACT of the TREASURER'S ACCOUNTS for the Year ending 30th September, 1904.

CASH ACCOUNT.

RECEIPTS.

To Cash in Bank on Deposit,	£145	0	0			
,, Cash in Treasurer's hands,	5	5	8			
				£150	5	8
,, Subscriptions for current year (including 16 new Members)—						
164 at 10/-,				82	0	0
Do. do. —2 at 7/6,				0	15	0
,, Arrears—6 at 10/-,				3	0	0
,, Associate Members' Subscriptions—9 at 2/6,				1	2	6
,, Publications sold,				3	17	3
,, Interest on Funds,				7	11	6
				£248	11	11

EXPENDITURE.

By Printing and Publishing Supplement to Vol. XII. of *Transactions*,				£21	10	6
,, Library—						
New Books, Maps, and Magazines,	£4	14	5			
Bookbinding,	10	1	9			
Librarian's Disbursements,	2	8	9			
				17	4	11
,, Subscription to Marine Biological Association, 1903,	£1	1	0			
,, Subscription to Palæontographical Society, 1904,	1	1	0			
,, Rent, Insurance, and Attendance,	13	17	6			
,, Printing and Postage of Circulars,	19	4	1			
,, Lantern Expenses,	1	10	0			
,, Delegates' Expenses to Sanitary Congress,	1	1	0			
,, Collector's Commission,	2	8	9			
,, Disbursements by Honorary Secretaries, Postages, Stationery, and Petty Expenses,	6	1	10			
				46	5	2
,, Cash in Bank on Deposit,	£158	0	0			
,, Cash in Treasurer's hands,	5	11	4			
				163	11	4
				£248	11	11

STOCK ACCOUNT.

To Life Subscriptions Account,	£246	15	0	By Campbeltown Corporation Loan,	£170	0	0
,, Capital Account,*	586	16	4	,, Cash in Bank and on hand,	163	11	4
					£333	11	4
				,, Property—			
				Books in the Library,	£440	0	0
				Furniture, Bookcases, and Microscope,	60	0	0
					500	0	0
	£833	11	4		£833	11	4

* NOTE.—Subject to cost of Publishing *Transactions*.

GLASGOW, *27th October*, 1904.—Examined, compared with relative Vouchers and Securities, and found correct, the balance in Treasurer's hands being Five Pounds Eleven Shillings and Fourpence.

ARCH. A. YOUNG,
JOHN RENWICK, } *Auditors.*

Digitized by Google

INDEX TO VOLUME XII.

1900-1905.

PAGE

Abstract of Treasurer's Accounts for 1899, ... 123
,, ,, ,, 1900, ... 124
,, ,, ,, 1901, ... 271
,, ,, ,, 1902, ... 272
,, ,, ,, 1903, ... 417
,, ,, ,, 1904, ... 418
Ailsa Craig, Notes on Excursion to, ... 103
Alaskan Sand, ... 401
Altered Coal, ... 398
Antarctic Speculation. By James Anderson, ... 167
Apiocrinus, Fresh Points in the Structure of. By A. L. du Toit, 187
Arran, Tertiary Volcanic Vent in the Island of. By James Stark, 196
"Ausweichung" or Strain-slip in Schistose Rocks, Notes on the Development of. By Peter Macnair, ... 89

Barr, Mr. Thomas M., Notice of, ... 256
Basin of Annick Water, Notes on, ... 410
Bennie, Mr. James, Notice of, ... 110
Bothriolepis from Heads of Ayr, ... 406
Boulder-clay at Hamilton Hill, North of Glasgow. By John Smith, 65
Boulders and other Evidence of Ice-action in Lochaber. By Colin Livingston, ... 39

Cambrian Fauna of the North-west Highlands. By B. N. Peach, 223
Camp Siluria. By Peter Macnair, ... 203
Camp Siluria, Life in, ... 112
Carboniferous Fish Remains, Some new, ... 405
Carboniferous Limestones of Scotland, with their Coals. By R. W. Dron, ... 66
Causes of Volcanic Action. By J. G. Goodchild, ... 145
Chalcedony Geodes, ... 408
Cinnabar from Servia, ... 406
Circuit of Arran and Ancient Sea Levels, ... 96
Columnar Structure, Photographs of, ... 401

Digitized by Google

PAGE
Columnar Structure in Glass Mortar, ... 254
Columnar Structure, Theory of. By John Wallace, ... 234
Constitution and Laws of the Society, ... 127
Craig, Mr. Robert, Notice of, ... 110
Crannogs, Geology of Clyde. By James Neilson, ... 273
Critique of "The Glacial Deposits of Ayrshire," 97
Crustaceans from Silurian Rocks, ... 112
Crystals dredged from Clyde, ... 400
Crystallisation of Rocks. By Frederick Mort, ... 311
Crystallised Carbonite. By John Smith, ... 308

Day on Ben More, Assynt, ... 260
Difficulties of a Young Geologist, ... 403
Discoverer of Thelodus, ... 400
Discussion of Paper on Parallel Roads,... 410
Dolerites of Glasgow District, ... 398
Drain Section near Thornliebank. By James Neilson, ... 294
Drawn-out Spherulitic Structure in a Trap Dyke near Balloch Pier, Great Cumbrae. By John Smith, ... 62
Dykes at Loch Ranza, Arran, ... 406

Egypt, Physical Geography and Geology of. By Mathew Blair, 173
Elvanfoot to Wanlockhead Railway, Geology of. By John Smith, 81
Evening Excursions in 1899, ... 117
Evening Excursions in 1900, ... 122
Evening Excursions in 1901, ... 264
Evening Excursions in 1902, ... 265
Evening Excursions in 1904, ... 416
Excavations in Glasgow, Notes on. By John Wallace, ... 220
Excursions for 1899, ... 115
Excursions for 1900, ... 118
Excursions for 1901, ... 261
Excursions for 1902, ... 265
Excursions for 1903, ... 412
Excursious for 1904, ... 412

Faröe Islands, Mineralogy of. By M. Forster Heddle, ... 1
Farquhar, Notice of Bailie John, ... 245
Fault in Arran, Highland Boundary. By James Stark, ... 292
Fenestella, ... 403
Fish-Fauna of Upper Old Red Sandstone, ... 404
Fish Remains from Silurian Rocks, ... 112
Flexed Structure in the Pitchstone of Corriegills, Arran. By John Smith, ... 61
Fossil Fish from Orange Free State, ... 95
Fossil Shells from Labuan, ... 111

Digitized by Google

PAGE
Fossil Wood, ... 401
Fresh Points in the Structure of Apiocrinus. By A. L. du Toit, 187
Freshwater Limestone underlying a Marine Limestone near Paisley. By John Smith, ... 64
Fulgurites, ... 97

Gareland Cleuch, ... 409
Geology of Elvanfoot to Wanlockhead Railway (with special reference to the Drift). By John Smith, ... 81
Geology of the Mediterranean Seaboard. By James Stark, ... 159
Geology of North Berwick, ... 92
Geology of Portrush. By James S. M'Lennan, ... 180
Geology of Rouken Glen. By Peter Macnair, ... 362
Geology of Wanlockhead and Leadhills, ... 401
Glaciers of Illecillewaet, ... 111
Globular Structure in a Trap Rock near Neilston, Renfrewshire. By John Smith, ... 62
Goldfield of North-West Ontario, Canada. By R. W. Dron, ... 58
Granite, The Origin of. By James Anderson, ... 236
"Green Beds" on Sron Aonaich and near Ardlui. By Peter Macnair, 231

Highland Grits and Quartzites, ... 255
Homosteus Milleri, ... 99
Hugh Miller and his Palæichthyological Work, ... 257

Ice Cap and Parallel Roads of Lochaber. By Colin Livingston, ... 326
Intrusive Rocks, Origins of. By J. G. Goodchild, ... 305
Iron Crystals from Slag, ... 408

Jurassic and Liassic Rocks of Yorkshire Coast, ... 111

Landscape Marble, ... 409
Laterite and Silicified Wood from Burma, ... 259
List of Members in May, 1902, ... 135
Lithology, A Geologist's Idea of, ... 407
Lochaber, Boulders and Other Evidences of Ice Action in. By Colin Livingston, ... 39
Loch Maree District, Geology of, ... 258
Loch Tay Limestone, Outlier of. By Peter Macnair, ... 318
Lower Carboniferous Rocks of Northern Britain. By J. G. Goodchild, ... 16

Maps, Gift of. By Mr. Jolly, ... 100
Maps, Resolution regarding Colour Printing of, ... 411
Marginal Zone of the Central Highlands in the Loch Lomond—Aberfoyle Area. By A. L. du Toit, ... 253

Digitized by Google

PAGE

Marine Deposit from Table Bay, ... 96
Mediterranean Seaboard, Geology of. By James Stark, ... 159
Mineralogy of the Faröe Islands. By M. Forster Heddle,... ... 1
Minerals, Rare Renfrewshire. By Robert S. Houston, ... 354
Moraine at Caticol, Arran, ... 406
More Important Groups of Carboniferous Plants. By Robert Kidston, ... 246
Murdoch, J. B., Obituary Notice of, ... *To face* 273

New Zealand, Description of, ... 402
New Zealand Sands, ... 401
Notes on the Development of "Ausweichung" or Strainslip in Schistose Rocks. By Peter Macnair, ... 89
Notes on Famous Fossils in Continental Museums, ... 98
Notes on the Geology and Archæology of Syria and Palestine. By James Neilson, ... 239
Note on Lake Basins being carved out of Rock by Glacier Ice, ... 101
Notes on a New Section of Orchard Limestone, and on Outcrops of the Neighbouring Limestones, ... 107
Notes on a Recent Excavation in Sauchiehall Street, Glasgow. By John Wallace, ... 79
Notes on a Recent Trip to Egypt. By James Neilson, ... 226
Notes on Scottish Carboniferous Lamellibranchiata, ... 98
Notes on the Shoals at Caticol Point and Kirn Point, Arran. By Charles R. Cowie, ... 156

Obituary Notice of J. B. Murdoch, of Capelrigg, ... *To face* 273
Objects of the Society, ... 126
Office-Bearers of the Society for Session 1901-1902, ... 134
Old Red Sandstone, Fish Fauna of, ... 404
Ore Deposits, and how they are formed. By G. R. Thomson, ... 244
Origins of Intrusive Rocks. By J. G. Goodchild, ... 305
Outlier of Loch Tay Limestone. By Peter Macnair, ... 318

Palæoxyris from Ayrshire, ... 407
Parallel Roads of Lochaber. By Colin Livingston, ... 326
Pectolite from Dalry, ... 408
Pectolite from Lendalfoot, ... 107
Perlitic Structure in Volcanic Glass, ... 95
Photograph of Chilian Miner, ... 102
Photograph of Rumbling Bridge Excursion, ... 409
Physical Geography and Geology of Egypt. By Mathew Blair, ... 173
Pitchstone of Corriegills, Arran, Flexed Structure in the. By John Smith, ... 61
Plutonic Complex at Tomnadashan, Loch Tay, Perthshire. By Peter Macnair, ... 247

Digitized by Google

PAGE
Portincross, Ayrshire, Shore Section at. By James Stark, ... 74
Portrush, Geology of. By James S. M'Lennan, ... 180
Portrush, Geology of, ... 107
Posidonomya and Estheria, ... 399
Problem of the Marginal Highlands, ... 97
Proceedings for Session 1899-1900, ... 92
Proceedings for Session 1900-1901, ... 104
Proceedings for Session 1901-1902, ... 242
Proceedings for Session 1902-1903, ... 251
Proceedings for Session 1903-1904, ... 398
Proceedings for Session 1904-1905, ... 404
Productus from Coal Measures, ... 403
Publications of the Society, ... 144

Rare Renfrewshire Minerals. By Robert S. Houston, ... 354
Recent Work in Camp Siluria, ... 399
Red Quartzite Pebbles and Quartz Pebbles, ... 102
Reflecting Gonometer, ... 403
Report of the Council for 1898-1899, ... 92
,, ,, 1899-1900, ... 104
,, ,, 1900-1901, ... 242
,, ,, 1901-1902, ... 251
Report on the Library for 1898-1899, ... 94
,, ,, 1899-1900, ... 106
Rocks, Crystallisation of. By Frederick Mort, ... 311
Rocks in the Islands of Loch Fyne, ... 95
Rocks, Structure of. By Frederick Mort, ... 290
Rouken Glen, Geology of. By Peter Macnair, ... 362

Sandstone with Annelid Casts, ... 108
Shoals at Caticol Point and Kirn Point, Arran, Notes on. By Charles R. Cowie, ... 156
Shore Section at Portincross, Ayrshire. By James Stark, ... 74
Speculations on Surface Geology, ... 108
Stalactites and Geyserite, ... 409
Staurocephalites serrula, ... 100
Stroll along a Trap Dyke in Ayrshire. By J. S. M'Lennan, ... 214
Structure of Aberfoyle Region, ... 400
Structure of Igneous Rocks. By Frederick Mort, ... 290
Struvite from Hamburg, ... 259
Surface Geology of the Falls of Clyde District. By James Stark, 52

Tertiary Volcanic Vent in the Island of Arran. By James Stark, 196
Thelodus, Original Discoverer of, ... 400
Thomson, James, Notice of, ... 102
Transvaal Geology and Premier Diamond Mine, ... 408
Trap Sills, ... 402

Digitized by Google

PAGE

Vertebrate Animals of the Coal Period. By R. H. Traquair, ... 224
Volcanic Action, The Causes of. By J. G. Goodchild, ... 145
Volcanic Ash with Beds of Sand and Gravel, near Neilston, Renfrewshire. By John Smith, ... 63
Volcanic Dust from Barbadoes, ... 249
Volcanic Series associated with the Schists of North Glen Sannox, Arran. By William Gunn, ... 192
Volcanoes: Their Causes and Effects. By J. G. Goodchild, ... 228

Wanlockhead and Leadhills, Geology of, ... 401
Water-divining, ... 408

Young, Dr. John, Notice of, ... 99

Printed by Wm. Hodge & Co., Glasgow and Edinburgh.

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

PUBLICATIONS OF THE SOCIETY.

TRANSACTIONS.—Demy 8vo.

Vol. I. Part 1.—The Geology of the Campsie District. By John Young, LL.D., F.G.S. (3rd edition, revised), 2/
——— Part 2.—The Phenomena of the Glacial Drift of Scotland. By Sir Archibald Geikie, F.R.S. (*Reprint*), - 5/
Vol. II. Part 1.—Papers on Local and Theoretical Geology, - - 4/6
——— Part 2.— Do. do. do. (*Out of Print*).
——— Part 3.— Do. do. do. - - - 4/6
Vol. III. Part 1.— Do. [contains "On Geological Time." By Lord Kelvin, F.R.S.], - - - 4/
——— Part 2.— Do. [contains "On Geological Dynamics." By Lord Kelvin, F.R.S.], - - 4/
——— (Supplement)—On the Carboniferous Fossils of the West of Scotland. By John Young, LL.D., F.G.S., and James Armstrong, - - (*Out of Print*).
Vol. IV. Part 1.—Papers on Local and Theoretical Geology, - - 3/
——— Part 2.— Do. do. do. - - 3/
——— Part 3.— Do. do. do. - - 3/
Vol. V. Part 1.— Do. do. do. - - 4/
——— Part 2.— Do. [contains "Geological Climate." By Lord Kelvin, F.R.S.], - - - 4/
Vol. VI. Part 1.— Do. [contains "The Internal Condition of the Earth." By Lord Kelvin, F.R.S.], 4/
——— Part 2.—Papers on Local and Theoretical Geology, - 4/
Vol. VII. Part 1.— Do. do. do. - 5/
——— Part 2.— Do. do. do. - 5/
Vol. VIII. Part 1.— Do. do. do. - 5/
——— Part 2.— Do. [contains "Polar Ice Caps and their Influence in changing Sea Levels." By Lord Kelvin, F.R.S.], - - - - 5/
Vol. IX. Part 1.—Papers on Local and Theoretical Geology, - 6/6
——— Part 2.— Do. do. do. - 6/6

All parts in hand up to this date may be had by members at a very reduced price.

Vol. X. Part 1.—Papers on Local and Theoretical Geology, - 6/6
——— Part 2.— Do. do. do. - 7/
Vol. XI. Part 1.— Do. do. do. - 6/
——— Part 2.— Do. do. do. - 7/
——— (Supplement)—Drift Deposits of Ayrshire. By John Smith, - - - - - - - - 4/
Vol. XII. Part 1.—Papers on Local and Theoretical Geology, - - 5/
——— Part 2.— Do. do. do. - - 5/
——— Part 3.— Do. do. do. - - 5/

PALÆONTOLOGICAL SERIES.—Demy 4to.

Part 1.—Containing Four Plates with many Figures, - - 3/6

CATALOGUE OF WESTERN SCOTTISH FOSSILS.

Compiled for the Meeting of the British Association, 1876. Crown 8vo, 2/6
Do. do. do. interleaved, 3/6

GEOLOGY OF THE CLYDE DRAINAGE AREA.

Compiled for the Meeting of the British Association, Glasgow, 1901. Demy 8vo, paper boards, - - - - 1/; interleaved, 1/6

THE GEOLOGY OF THE CAMPSIE DISTRICT.

By John Young, LL.D., F.G.S. Third edition, 1894. Demy 8vo, - 2/

THE PHENOMENA OF THE GLACIAL DRIFT.

By Sir Archibald Geikie, F.R.S. (*Reprint.*) Demy 8vo, - - - 5/

THE DRIFT OR GLACIAL DEPOSITS OF AYRSHIRE.

By John Smith. Demy 8vo, - - - - - - - - - 4/

Copies of the above from the Hon. Libn., Mr. J. S. M'LENNAN, at the Society's Rooms, 207 Bath Street, Glasgow; *or through any Bookseller.*

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

B'D NOV 12 1914

Digitized by Google

Digitized by Google